

**Parenting and Effortful Control:
An EEG Study**

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Thesis declaration form

I confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

Signature:

Name:

Date:

Overview

The aim of this thesis was to investigate the relationship between early quality of care and the development of effortful control.

Part 1 is a meta-analytic investigation into the relationship between observed maternal parenting and child effortful control. The paper investigates an estimate of overall effect size, the effect of publication bias and key methodological and demographic moderators of the relationship.

Part 2, the empirical paper, reports a 5 year longitudinal study into the relationship between early quality of care and later effortful control. Maternal Behaviour and Dyadic Interaction were assessed at age ten months using the Coding Interactive Behaviour scales (CIB; Feldman, 1998). Effortful control was assessed at age six years using the executive attention component of the Attention Network Task (Fan, McCandliss, Sommer, Raz and Posner, 2002). This was an EEG study which included investigation into the LPC and N2 neural indices of effortful control and their relationship to early quality of care. Parent-reported effortful control was assessed using the Child Behaviour Questionnaire (CBQ), Executive Function with the Behaviour Rating Inventory of Executive Function (BRIEF) and behaviour with the Strengths and Difficulties Questionnaire (SDQ).

Part 3 provides a critical appraisal of the research process. It considers conceptual and methodological issues and the clinical utility of the research findings.

This thesis was conducted jointly with Sophie Bennett (see Appendix 6).

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Part 1: Literature Review

Relationship Between Early Quality of Care and Effortful Control: A Meta-Analysis

Abstract

Aims: This paper aims to examine the strength of the relationship between parenting and the development of effortful control, and the factors moderating this relationship.

Methods: A systematic review was conducted to identify studies investigating the association between observed parenting quality and the development of effortful control. Meta-analysis of effect sizes and methodological and demographic moderators was conducted on 31 independent data sets (N=7910-7924).

Results: Higher quality of parenting was associated with greater child effortful control ($r=.17$, $p<.001$, 95% CI=.12-.21). The effect was larger ($Q=4.25$, $p=.039$) for emotional aspects of parenting ($r=.19$, $p<.001$) than limit-setting ($r=.11$, $p<.001$). Effect size did not differ between observational and questionnaire assessments of effortful control ($Q=0.50$, $p=.478$) and was greater ($Q=4.16$, $P=.041$) for middle class ($r=.19$, $p<.001$) versus socioeconomically disadvantaged families ($r=.11$, $p<.01$). Meta-regression indicated a significant relationship between overall effect size estimates and ethnicity (slope=.003, $p=.010$) and the percentage of families cohabiting (slope=.005, $p=.011$), which together accounted for 61.3% of between-study variability.

Conclusions: The relationship between parenting and the development of effortful control is small but highly significant and greatest for emotional aspects of parenting and families at low demographic risk. All the included studies utilised assessments of effortful control reliant on parent-report or researcher scoring/rating. Recommendations for future research include examining the role of different parenting behaviours, elucidating mechanisms of the association, assessing the role of demographic factors and paternal behaviour, investigating clinical and high risk populations and investigating objective measures of effortful control.

Introduction

The understanding of self-regulation has been described as *'the single most crucial goal for advancing an understanding of development and psychopathology'* (Posner and Rothbart, 2000). Self-regulation is a broad term, used to describe the ability, emerging during childhood, to regulate emotion and plan and control behaviour (Rothbart, Posner and Kieras, 2006). Karreman, van Tuijl, van Aken and Dekovic (2006) distinguish a number of categories of self-regulation: compliance, inhibition, emotion-regulation, and effortful control. These abilities in childhood are an important predictor of long term behavioural and emotional adjustment and functioning (for a review see Eisenberg, Smith & Spinrad, 2013, pp267-273). Accordingly, the environmental influence on this developmental process has received significant research attention, perhaps none more so than parenting.

Effortful Control

Effortful control is considered a key component of self-regulation (Berger, Kofman, Livneh and Henik, 2007) and defined as *'the ability to inhibit a dominant response in order to perform a subdominant response'* (Rothbart and Bates, 1998). It is a temperamental trait, arising as a result of 'genetic endowment' and influenced by one's experiences (Rothbart and Rueda, 2005).

The factor structure of parent-reported effortful control has been found to be invariant across sex and ethnicity (Sulik, Huerta, Zerr, Eisenberg, Spinrad, Valiente et al., 2009) and consistent across a range of parent-report measures and behavioural tasks (Kochanska, Murray & Harlan, 2000; Kochanska & Murray, 2002). Effortful control abilities emerge during infancy, consolidate during the second year of life and continue to develop through childhood (for a review see Rothbart et al., 2006). Measures of effortful control are longitudinally stable (Kochanska, et al., 2000; Kochanska and Murray, 2002), with increasing coherence across measures from age two years (Kochanska et al., 2000).

Effortful Control and Outcomes

The development of effortful control has been described as crucial in the development of self-regulation (Berger et al., 2007). There is substantial evidence for the importance of effortful control for later social, emotional, behavioural and academic adjustment and functioning.

Children with higher levels of effortful control have been consistently found to exhibit fewer externalising behaviour problems, (Eisenberg, Spinrad, Fabes, Reiser, Cumberland, Shepard et al, 2004; Kochanska and Knaack, 2003; Olson, Sameroff, Kerr, Lopez, Nestor & Wellman, 2005; Spinrad, Eisenberg, Gaertner, Popp, Smith, Kupfer et al., 2007; Valiente, Lemery-Chalfont & Reiser, 2007). There is also good evidence for this association persisting into the adolescent years, with lower levels of effortful control continuing to be associated with higher levels of problem behaviours (Ellis, Rothbart & Posner, 2004; Loukas & Roalson, 2006; Muris, 2006; Willem, Bijttebier & Claes, 2010). Higher levels of effortful control in children have also been associated with moral development and the development of conscience (Kochanska and Knaack, 2003; Kochanska, Murray and Coy, 1997) and increased social competence (Blair, Denham, Kochanoff & Whipple, 2004; Dennis, Brotman, Huang & Gouley, 2007, Fabes, Eisenberg, Jones, Smith, Guthrie, Poulin et al., 1999; Spinrad et al., 2007). Effortful control has also been identified as the '*primary temperament domain involved in liability to ADHD*' (Nigg, Goldsmith and Sachek, 2004).

Effortful control is also important for the development of emotion regulation. Children with higher concurrent effortful control have been found to modulate anger and regulate joy better (Kochanska et al., 2000) and show lower levels of separation distress (Spinrad et al., 2007). Levels of inhibitory control have been shown to correlate significantly with both emotion understanding and the ability to regulate expression both positive and negative emotion (Carlson & Wang, 2007). A similar association has been demonstrated between levels of socially appropriate emotional

expression and effortful control (Kieras, Tobin, Graziano & Rothbart, 2005; Simonds, Keiras, Rueda & Rothbart, 2007).

Higher levels of effortful control also appear to confer advantages in the classroom. In preschoolers, higher levels of effortful control are significantly associated with early maths and literacy skills (Blair & Razza, 2007; McClelland, Cameron, Connor, Farris, Jewkes & Morrison, 2007) and through first and second grade (Liew, Chen & Hughes, 2010), with the effect for reading continuing into third grade (Liew, McTigue, Barrols & Hughes, 2008). In older children, aged seven to twelve, higher levels of effortful control tend to remain associated with academic competence (Valiente, Lemery-Chalfant & Castro, 2007).

Effortful Control and Parenting

Both Kopp (1982) and Fonagy and Target (2002) identify the parent-child relationship as the medium through which self-regulation and specifically, effortful control, are learned. Kopp (1982) proposes that interaction with parents in the early years of life fosters the development of increasingly sophisticated regulation. According to Kopp's (1982) theory, during infancy parents manage the infant's arousal, encourage the infant's focus on salient features of the environment and elicit and support attention shifting through reciprocal interaction with their infant. In toddlerhood, Kopp (1982) proposes that reciprocal interactions between parent and child support the development of self-initiated monitoring of behaviour. Fonagy and Target (2002) argue that the key function of the attachment relationship is the control of distress, and since the control of distress requires attentional processes, particularly through the use of distraction as a soothing technique, attention abilities must therefore develop within this mother-infant relationship.

The work of Nancy Eisenberg and colleagues has demonstrated associations between parent-reported effortful control and maternal warmth (Eisenberg, Zhou, Losoya, Fabes, Shepard, Murphy et al., 2003) positive and

negative emotional expressivity (Eisenberg, Gershoff, Fabes, Shepard, Cumberland, Losoya et al., 2001), sensitivity (Spinrad, Eisenberg, Silva, Eggum, Reiser, Edwards et al., 2012) and teaching strategies (Eisenberg, Vidmar, Spinrad, Eggum, Edwards, Gaertner et al., 2010).

In these studies, effortful control was assessed using the 195-item Child Behaviour Questionnaire (CBQ; Rothbart, Ahadi, Hershey, & Fisher, 2001) which requires parents to rate statements about their child on a seven-point Likert scale. Factor analysis of this questionnaire identifies a three factor structure comprising effortful control, as well as negative affectivity and extraversion/surgency (Putnam, Gartstein & Rothbart, 2006; Rothbart et al., 2001). Dimensions loading onto the effortful control factor are the 'Attentional Focusing,' 'Inhibitory Control,' 'Low Intensity Pleasure' and 'Perceptual Sensitivity' subscales. Versions of the questionnaire exist for assessment of children throughout childhood (Infant Behaviour Questionnaire, Rothbart, 1981; Gartstein & Rothbart, 2003; Early Childhood Behaviour Questionnaire, Putnam et al., 2006; Temperament in Middle Childhood Questionnaire, Simonds & Rothbart, 2004; Early Adolescent Temperament Questionnaire, Ellis & Rothbart, 2001).

Studies investigating performance on multi-task behavioural batteries assessing effortful control have also demonstrated associations with maternal power assertion (Kochanska & Knaack, 2003), maternal responsiveness (Kochanska et al., 2000) and maternal positive control (Karreman, van Tuijl, van Aken & Dekovic, 2008). The most commonly used behavioural assessment battery of effortful control is Kochanska and colleagues' effortful control battery (Kochanska et al., 2000; Murray and Kochanska, 2002). These tasks are theoretically derived from Rothbart's definition (Rothbart & Bates, 1998) of effortful control and based on five components which each share this definition: delaying, slowing down motor activity, suppressing or initiating activity in response to a signal, effortful attention and lowering voice (Kochanska et al., 2000).

Numerous computerised tasks also exist to measure 'executive attention,' proposed to be the underlying mechanism of effortful control (Rothbart, Sheese and Posner, 2007). These include spatial conflict tasks (e.g. Rothbart, Ellis, Rueda and Posner, 2003), Go No-Go tasks (e.g. Simpson & Riggs, 2006; Wiebe, Sheffield & Espy, 2012) and the flanker (Eriksen and Eriksen, 1974) or 'executive' component of the 'Attention Network Task' (Fan, McCandliss, Sommer, Raz and Posner, 2002). These tasks are generally conducted on computer, reaction times and accuracy are recorded, and minimal interaction is required. Accordingly, these tasks arguably offer a more objective measure of ability, although performance remains significantly associated with parent-reported effortful control (Chang & Burns, 2005; Simonds et al., 2007; Gerardi-Caulton, 2000).

Few studies, however, have chosen this method of assessment in assessing the association between early experiences of parenting and later effortful control. One notable exception is the recent large, longitudinal study of early childcare experiences and child development, the National Institute of Child Health and Human Development Early Childcare Research Network (NICHD ECRN). This study found a significant association between maternal sensitivity and rates of errors of commission on the Continuous Performance Task (Belsky, Fearon & Bell, 2007).

Previous Reviews

There now exists a wealth of literature examining the role of numerous aspects of parenting in the development of effortful control, measured both behaviourally and using parent-reported measures. A recent narrative review of this literature (Kiff, Lengua & Zalewski, 2011) concluded that parenting consistently predicts the development of effortful control in early childhood, with moderate effect sizes, describing parenting as '*an important force in shaping children's self-regulation and effortful control.*'

Although a helpful synthesis of the current literature, narrative reviews can be limited by unconscious or conscious bias in the description and evaluation of conflicting research findings and provide only a qualitative account of the field of evidence (Rosenthal & DiMatteo, 2001). In addition, the method of collating relevant papers is not reported by Kiff, Lengua and Zalewski (2011) and it is therefore difficult to ascertain the scope of the papers included, and the extent of bias in the sampling of these papers (Cook, Mulrow & Haynes, 1997).

Furthermore, many of the studies evaluated in Kiff, Lengua and Zalewski (2011) relied on self-report measures of parenting, considered to be of questionable reliability and validity (Morsbach & Prinz, 2006; Perepletchikova, & Kazdin, 2004) and requiring further research investigation for their improvement (Krevans & Gibbs, 1996; Locke & Prinz, 2002). Indeed, comparison of self-report measures with behavioural observation has established substantial bias and error in self-report measures (Baker & Brandon, 1990; Belli, Traugott, Young & McGonagle, 1999). The review also incorporated studies investigating the related, but not synonymous construct of 'self-regulation.' Whilst effortful control is considered key to self-regulation, this is frequently used as a broader term which also incorporates the distinct constructs of compliance and emotion regulation (Karreman et al., 2006).

Finally, the empirical studies described above, investigating associations between parenting and effortful control, demonstrate substantial variation in the parenting constructs and parental behaviours investigated. Increasingly, there is a distinction between emotional aspects of parenting such as warmth, sensitivity and positive expressivity, and those relating to structure, control and limit-setting, both theoretically (e.g. Maccoby, 2000) and in reviews of the literature investigating parenting (Karreman et al., 2006; Kiff, Lengua & Zalewski, 2011; McLeod, Weisz & Wood, 2007). There has, as yet, been no meta-analytic investigation into whether or how these two distinct elements of parenting might be associated with effortful control.

The Current Study

This study aims to build on current understanding of the relationship between quality of parenting and the development of effortful control using quantitative meta-analysis to generate an estimate of the overall strength of the association between these two variables. A systematic search was conducted, to identify papers investigating the association between observed measures of parenting and the clearly defined outcome of effortful control. Quantitative meta-analysis investigating the associations between parenting and the development of self-regulation has not, thus far, included consideration of effortful control, due to a paucity of studies (Karreman et al., 2006). It is hypothesised that higher quality parenting will be associated with higher levels of effortful control, and further that this association may differ as a consequence of the parenting construct investigated (emotional aspects versus those related to structure and limit-setting). The study also aims to explore whether the study methodology, design and sample demographic factors moderate the magnitude of the relationship.

With respect to methodology, factors related to the method of assessment of parenting such as (1) the location of assessment, (2) the nature of activity observed (structured or unstructured) and (3) the rating method (observer impressions or event coding), and to the assessment of effortful control (behavioural or questionnaire) are explored. It is hypothesised that effect sizes of greater magnitude may be associated with studies utilising more structured and objective (conducted in the laboratory, using event coding rather than observer impressions) assessments of parenting.

Elements of study design such as the age at which parenting and effortful control were assessed and whether the effect size reflects concurrent or longitudinal assessment are also investigated. Consistent with the idea that parenting plays a role in the development of effortful control throughout childhood, it is hypothesised

that the age of assessment should not moderate the relationship between parenting and child levels of effortful control.

Finally, demographic factors such as socioeconomic status, ethnicity, gender ratios of the sample were also investigated. These factors have been demonstrated to be associated with the development of effortful control and related abilities (Hackman & Farah, 2009; Lengua, Bush, Long, Kovacs & Trancik, 2008; Mezzacappa, 2004) and thus may well be considered risk factors (e.g. Fearon & Belsky, 2004) likely to moderate the association between parenting and the development of effortful control.

Method

Search Strategy

The electronic databases PsychInfo, MedLine, Embase and Web of Science were systematically searched for studies investigating a quantitative relationship between an observed measure of parenting and a measure of effortful control. The search was restricted to articles published in English in peer-reviewed journals in the last 25 years, where research participants were children aged up to 12 years.

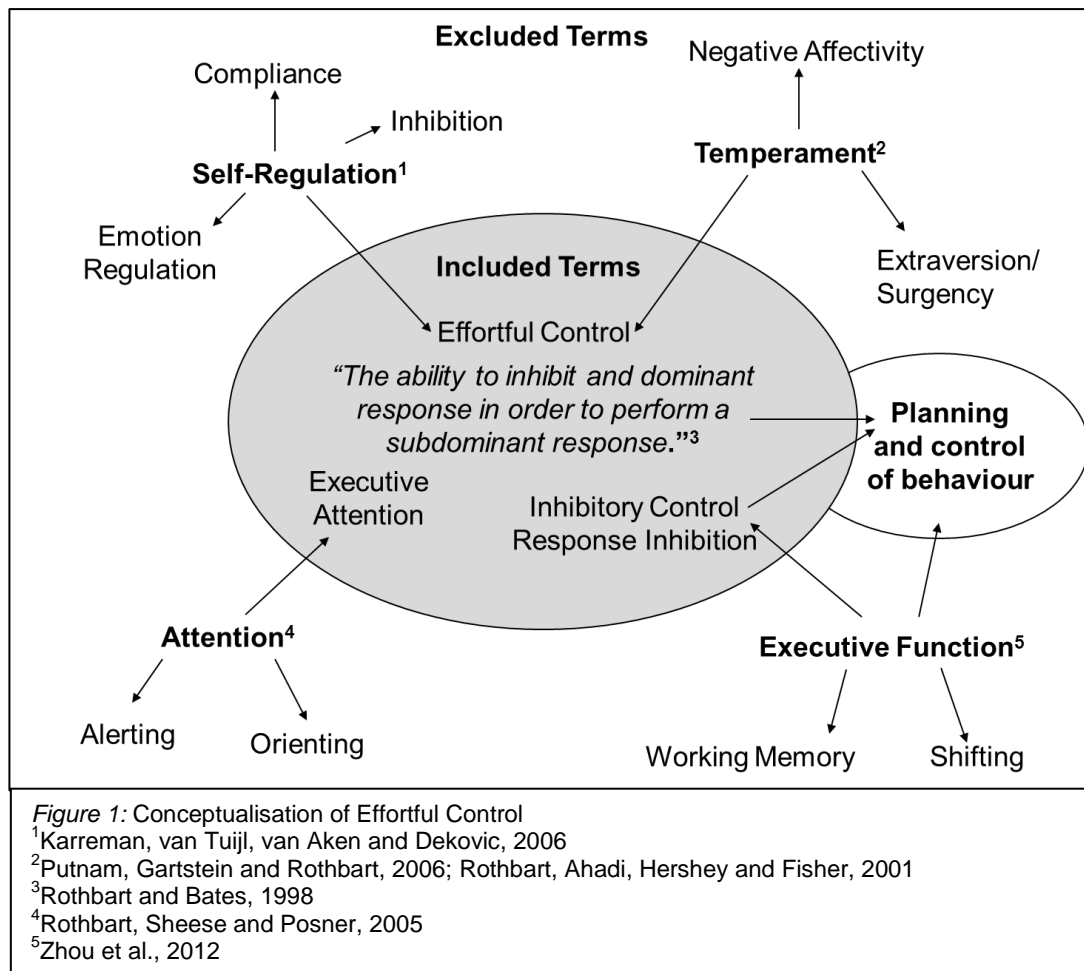
Search Terms

The searches were conducted using the search terms listed in Table 1. Search results from the 'Parenting' search were combined with results from the 'Effortful Control' search using the operator 'AND.' Search terms in Psychinfo, MedLine and Embase included both Subject Headings and text, and were applied to the article title, abstract and additional headings used by the databases. Searches in Web of Science were applied to both the article Topic and Title. Search hits in Web of Science were further limited by 'Research Area' to exclude papers from non-relevant research fields such as 'Engineering' and 'Surgery.'

Defining Effortful Control

Within the psychological literature there is considerable overlap between the constructs of 'effortful control,' 'executive attention' (Rothbart et al., 2007), 'executive function' (Zhou, Chen & Main, 2012) and 'self-regulation' (Karreman et al., 2006). Further discussion of unique and shared features of these constructs is beyond the scope of this report. For the purposes of defining search terms and inclusion and exclusion criteria, effortful control was conceptualised according to Figure 1. Effortful control was defined as '*the ability to inhibit a dominant response in order to perform a subdominant response*' (Rothbart and Bates, 1998). Those features of attention, executive function, self-regulation and temperament consistent with this definition (depicted inside the shaded area) were included as search terms. Planning and control of behaviour were conceptualised as higher-order executive functions to which effortful and inhibitory control contribute.

To ensure a sufficiently comprehensive search, the broader terms 'executive function' and 'self-regulation' were also used, and papers included where the abilities investigated were consistent with the definition of effortful control. The terms 'temperament' and 'attention' were too broad, yielding large numbers of papers which did not meet the inclusion criteria. Papers investigating constructs not consistent with the definition were excluded.



Parenting

Search terms were chosen to ensure a sufficiently comprehensive search of studies investigating parenting. Although predominantly a measure of child behaviour, the term 'Attachment' (Bowlby, 1977) was included. This was in order to ensure that any studies of mother-infant relationship with an attachment primary focus, but additional measures pertaining to this relationship, such as maternal sensitivity, were also included.

Table 1:

Search Terms for Systematic Literature Search

		Psycinfo	Embase	Medline	Web of Science
Parenting	Subject Heading	Attachment Theory Attachment Behaviour Attachment disorders Parent Child Relations Mother child relations Father child relations Parenting	Emotional attachment Child Parent Relations Mother child relations Father child relations Child rearing	Parent Child Relations Mother child relations Father child relations Parenting Child rearing	
	Text	Attachment Parenting	Attachment Parenting	Attachment Parenting	Parenting Attachment
All permutations of: mother/father/parent*/care* AND warmth/sensitiv*/relation*/child/infant/baby					
Effortful Control	Subject Heading	Self Regulation Response Inhibition			
	Text	"Effortful Control" "Response Inhibition" "Executive Function" "Inhibitory Control" attention adj network attention\$ adj control executive adj attention	"Self regulation" "Effortful Control" "Response Inhibition" "Executive Function" "Inhibitory Control" attention adj network attention\$ adj control executive adj attention	"Self regulation" "Effortful Control" "Response Inhibition" "Executive Function" "Inhibitory Control" attention adj network attention\$ adj control executive adj attention	"Self regulation" "Effortful Control" "Response Inhibition" "Executive Function" "Inhibitory Control" attention adj network attention\$ adj control executive adj attention

Subject Heading – Search terms mapped to the database system of subject headings drawn from the APA Thesaurus of Psychological Index Terms (Tuleya, 2007). **Text** – Terms searched as free text, not mapped to a system of subheadings.

* and \$ denote truncation, the symbol represents any number of additional characters; " " denotes the exact term was searched for; adj denotes a positional operator whereby retrieved records contain both search terms adjacent to each other; AND is a Boolean operator whereby retrieved records contain both search terms.

Inclusion Criteria

For inclusion in the meta-analysis, studies were required to meet the following criteria. Firstly, the study had to be published in a peer-reviewed journal published in English in the last 25 years. Secondly, the study had to include both a measure of observed maternal parenting and a measure of effortful control or equivalent ability, consistent with Rothbart & Bates' (1988) definition. Finally, the research had to have been conducted with typically developing children where all data were collected prior to the age of 12 years.

Studies where attempts had been made to recruit a 'high-risk' population, such as oversampling of children with externalising problems, or parental pathology such as maternal depression were included as these were conceptualised as risk factors for the development of child effortful control, rather than reflecting atypical neurodevelopment (see below).

Exclusion Criteria

Studies where the assessment of parenting included a self-report or child-report measure, whether contemporaneous or retrospective were excluded. Similarly, studies where the only measure of parent-child relationship was 'attachment' were also excluded since these are based primarily on observation of child, rather than parent, behaviour.

Studies were also excluded if the research was conducted exclusively with children or families with ADHD or other developmental disorders, medical conditions or syndromes associated with deficits in attention or executive function, including children born at very low birth weight and children subjected to abuse, neglect or severe institutional deprivation during the early years of their life.

Completeness of Search

To ensure an exhaustive search, the reference list of a recent review (Kiff, Lengua & Zalewski, 2011) and all papers in the study sample were investigated for further potentially relevant papers. This search did not yield any further results. However application of the search terms in 'Google Scholar' identified a further three papers which met inclusion criteria.

Search Results

The initial searches of the four databases yielded a total of 2,348 papers. Removal of duplicates resulted in 1,467 unique papers. Through inspection of the article title and abstract of these unique papers, a total of 196 were identified for possible inclusion. At this first stage, the main reasons for exclusion were that papers were not reporting empirical studies, or studies were conducted with only clinical or adult populations. The Methods and Results Sections of these papers were assessed in detail for evidence of whether the paper met the inclusion and exclusion criteria. From this assessment, 51 eligible papers were identified, representing 27 independent studies. Inclusion of the three papers identified during completeness searches resulted in a total of 54 eligible papers representing 29 studies reporting 31 independent data sets.

Multiple reports of same dataset

In cases where a number of papers reported results drawn from the same dataset, the study included in the meta-analysis was selected according to the following criteria. Firstly, the study with the smallest gap in time between measure of parenting and measure of effortful control was selected for inclusion, with the expectation that this would have the lowest rate of dropout. Secondly, and most commonly, the study selected was that with the largest sample size. Thirdly, where

all previous criteria are identical, the study reporting a Pearson's Correlation Coefficient (r) was chosen above those reporting other statistical analyses.

These criteria were sufficient for all but three circumstances. Firstly, identical data were reported in both Eiden, Colder, Edwards and Leonard (2007) and Eiden, Colder, Edwards and Leonard (2009) as well as in both Houck and LeCuyer-Maus (2004) and LeCuyer & Houck (2006). The earliest report of the data was therefore selected for inclusion. Secondly, Moilanen, Shaw, Dishion, Gardner and Wilson (2010) reported a composite measure of parenting and was thus chosen over Lunkenheimer, Dishion, Shaw, Connell, Gardner, Wilson et al. (2008). Finally, Mintz, Hamre & Hatfield (2011) was chosen over Belsky et al. (2007) since the CBQ measure of effortful control allowed for greater comparability to other studies than the Continuous Performance Task reported in Belsky et al. (2007).

Information Extracted

Information on the following methodological variables was extracted: site (location where the research took place), sample (community or high-risk), sample size, parenting construct (emotional aspects of parenting or those relating to control and structure), context of parenting observation (free interaction or a structured task), observation method (observer global ratings or event coding), the location of parenting assessment (home or laboratory), the method of effortful control assessment (behavioural or parent-report questionnaire) and the number of tasks or scales used in the effortful control assessment. The following demographic information of the sample was also coded: sex ratio (percentage boys), socioeconomic status (middle class or disadvantaged), ethnicity (percentage of children in the study who were Caucasian, or percentage of mothers if child data were not available), maternal age (at the birth of the child, computed by subtracting the mean age of the children at which maternal age was reported) and the

percentage of parents cohabiting at the start of the study. The coding schedule is included in Appendix 1.

All variables were initially coded by the author. A subset (21; 70%) of studies were subsequently coded by two second coders; ten (33%) by the first coder, an undergraduate student, and eleven (37%) by the second, a D.Clin.Psy. student. Inter-rater reliability was calculated using Pearson's r for continuous variables and % agreement for categorical variables. For continuous variables (N, Sex, SES, Ethnicity, Maternal Age, % Cohabiting and number of effortful control tasks), inter-rater reliability was very good (mean $r=0.99$, range=0.97–1.00). There were no discrepancies between codes for categorical moderators (agreement=100%). Differences in judgements regarding the continuous variables were resolved through discussion and consensus.

Effect sizes for the relationship between observed parenting and effortful control were also extracted. Where multiple effect sizes were reported, data were included according to the following criteria. Firstly, for concurrent studies where data were collected at only one time point, all the relevant effect sizes for the association between parenting and effortful control were extracted for inclusion in the meta-analysis, and a combined effect size computed. Secondly, for papers reporting longitudinal studies where data were recorded at only one time point (or where an average across time points had been calculated) for parenting and for effortful control, all relevant effect sizes were extracted and used to compute a combined effect size. For longitudinal studies where data from multiple time points were reported, the effect sizes from the earliest time points were extracted, to ensure consistency with the inclusion criteria for studies with multiple reports of the same dataset. Where these longitudinal studies had assessed effortful control at more than one age, the effect size relating to the first data collected was extracted, except in cases where effortful control had been assessed prior to age two. In these cases, the effect size relating to the first assessment of effortful control after age two

years was extracted. This is in accordance with evidence suggesting that behavioural assessment of effortful control becomes more reliable after the age of two years (Kochanska et al., 2000), and because validated behavioural measures of executive function begin at this age (Carlson, 2005).

Meta-Analytic Procedures

The meta-analysis was completed using the computer package 'Comprehensive Meta-Analysis 2.2.064' (CMA; Biostat, Inc, 2011). Firstly, for each study, a combined effect size (r) was calculated, using all effect sizes reported which met inclusion criteria. Effect sizes consistent with the hypothesis (a positive relationship between higher quality parenting and higher levels of effortful control) were assigned a positive sign; effect sizes contrary to the hypothesis were denoted as negative.

Random effects models were used in significance testing and moderator analyses. This is recommended since the results generated show less Type I error and more accurate Confidence Intervals than fixed effects models, thus ensuring a more conservative approach and robust and applicable findings (Hunter & Schmidt, 2000; Schmidt, Oh & Hayes, 2009). Fixed effects models assume the same population effect size underlies all the studies included in the meta-analysis. In contrast, random effects models assume random differences between studies as a consequence of multiple, unidentifiable sources of variation (procedure, measures, settings etc.) beyond that which can be explained by sampling error; that is, different underlying study populations (Raudenbush, 1994, pp301-305).

Meta-Analysis of effect sizes

Meta-analysis was first conducted on the full study set of 31 independent study sets drawn from 29 empirical papers to determine an estimate of combined effect size. Moderator analyses were subsequently conducted by comparing

combined effect sizes between specific subsets of studies. These contrasts were only conducted where at least two subsets contained at least four studies. Meta-regression of effect sizes and continuous moderator variables was conducted using Stata (StataCorp. 2011). Effect sizes (r) were first converted to standard mean differences and their standard errors were computed using CMA (CMA; Biostat, Inc, 2011).

Analysis of Evidence of Publication Bias

The 'trim-and-fill' method (Duval & Tweedie, 2000a, 200b) was used to calculate the effect of potential publication bias or data censoring on the results of the meta-analysis; the 'file-drawer problem' (Rosenthal, 1979). The effect size for each study is plotted against standard error to create a 'funnel plot.' The term 'funnel plot' refers to the shape of the array of data points which would be expected if the results of all studies were published. Larger studies are expected to generate a more precise estimate of effect size with smaller standard error; effect size data points should hence become increasingly spread as standard error increases, resulting in a funnel shape if no publication bias is present. Smaller studies finding nonsignificant effect sizes are less likely to be published (Mullen, 1989, pp35-42) and the omission of studies in the bottom left corner of the funnel plot therefore suggests publication bias. Using the 'trim-and-fill' method, the k rightmost studies considered to be unmatched on the left hand side are 'trimmed.' The missing counterparts to these studies are then imputed and plotted ('filled') as a mirror image of the 'trimmed' outcomes on the left hand side. An adjusted overall effect size and confidence interval can then be calculated.

A Classic Failsafe N analysis was also conducted (Rosenthal, 1979), to determine the number of unpublished studies which would increase the p value of the effect size to above the alpha level of 0.05.

Results

Final Study Sample

The final set of 31 independent datasets from the 29 studies reported in the results section were published between 1999 and 2012. Most studies (22) were conducted in the United States of America (USA), two were conducted in Canada and The Netherlands, one in the UK, one in Israel and one in Norway. The study set represented a total sample size of between 7910 and 7924 participants. Sample sizes ranged from 33 (Feldman, Greenbaum & Yirmiya, 1999) to 1363 (Mintz et al., 2011). Participants ranged in age at assessment of parenting from 13.2 weeks to 9.5 years, and assessment of effortful control from 22 months to 9.5 years. Nine (31%) of the studies had made efforts to recruit 'high-risk' samples, and five studies (17%) comprised samples of low socioeconomic status.

The average percentage of Caucasian children was 74% ranging from 5% (Li-Grining, 2007) to 100% (k=24). Two studies included samples with less than 50% Caucasian children, seven studies between 50 and 75% and fifteen with between 76 and 100%. A total of 66% of families contained two adults in the household (k=20), ranging from 33% to 100%.

Information regarding the study design, measures used and overall effect size included in the meta-analysis is reported in Table 2. Information regarding methodological and demographic moderators is displayed in Table 3.

Table 2:
Summary of Included Studies.

Paper	Design (Time gap) N	Sample	Parenting Measure (Age)	Parenting Task	Effortful Control Measure (age)	Overall Effect Size (r)
Bernier, Whipple and Carlson (2010)	L (13.4m) N=80 N=74	Community	Maternal Sensitivity (12.9m) Maternal behaviour Q Sort (Pederson & Moran, 1995), 90 items arranged in 9 clusters; scores then correlated against prototype to give a score between -1 and 1. Maternal mind-mindedness (12.9m) Meins, Fernyhough, Fradley and Tuckey (2001) coding system, Five categories of parental utterances coded as appropriate or inappropriate. Score is sum of appropriate comments in all five categories.	Unstructured, modelled on Pederson & Moran (1995) competing demands. Free play	<i>Conflict (26.3m):</i> Spin the Pots, Baby Stroop (Hughes & Ensor, 2005) Shape Stroop (Kochanska et al., 2000) <i>Impulse Control (26.3m):</i> Delay of Gratification (Kochanska et al., 2000)	0.193
Cipriano and Stifter (2010)	L (29.9m) N=66	Community	Maternal Behaviour (24.1m) Event coding at 5s intervals of parental behaviours: Redirection, Commands, Prohibitive statements, ignoring, social exchange, reasoning/explanation. Maternal Tone (24.1m) Coded at 5s intervals: positive, neutral or negative.	Playing with a 'boring' toy (Putnam & Stifter, 2005)	Behavioural (54m) Walk a Line Slowly (Murray & Kochanska, 2002) Delay of Gratification (Mischel & Ebbesen, 1970) Dinky Toys (Goldsmith & Rothbart, 1991) CBQ SF Mother and Father Report (54m) Inhibitory Control, Attentional Focussing, Smiling and Laughter, Perceptual Sensitivity, Low Intensity Pleasure, Attention Shifting	0.019
Eiden et al. (2007)	L (12m) N=227	Oversampling of alcoholic parents (recruited from birth records).	Sensitivity (24m) Negative Affect (24m) Warmth (24m) Clark, Musick, Scott & Klehr (1980) coding system of global 5-point rating scales.	Free play	Behavioural (36m) Snack Delay, Whisper, Lab Gift (Kochanska, Padavich & Koenig, 1996; Kochanska & Knaack, 2003).	0.250***

Paper	Design (Time gap) N	Sample	Parenting Measure (Age)	Parenting Task	Effortful Control Measure (age)	Overall Effect Size (r)
Eisenberg et al., 2001	C N=202	Children with CBCL T scores>60 (N=130) and age and sex matched with scores <60. (recruited from community).	Positive expressivity and warmth (73m) Negative expressivity (73m) Time sampling of intensity and duration of negative and positive facial expression every 30s.	Mother-child puzzle task; mother assists child to complete puzzle with verbal instruction, child cannot see puzzle	CBQ Mother (73m) Attention focusing, Attention shifting, Inhibitory Control (Goldsmith & Rothbart, 1991) Puzzle box task (73m) Persistence - Complete puzzle without looking and cheating	0.143*
Eisenberg et al., 2003	C N=153	Community	Warmth (112.8m) Global rating (smiling, laughing positive voice tone, verbal and physical affection) on 7-point scale.	Viewing 8 emotional photos with child and explaining content (Buck, 1975)	CBQ (112.8m) Attention focusing, Attention shifting, Inhibitory Control (Goldsmith & Rothbart, 1991) Puzzle box task (112.8m) Persistence - Complete puzzle without looking and cheating	0.185*
Feldman, Greenbaum and Yirmiya, 1999	L (21m) N=33	Community	Maternal Synchrony (3.3m) Monadic Phase Coding System (Tronick, Als & Brazelton, 1980)	Free play	Behavioural (24.3m) Self-regulated compliance (toy pick-up task). Delay act (temptation procedure, Feldman and Sarnat, 1986)	0.320
Gartstein and Fagot (2003)	C N=159	Community sample; aimed to include only two-parent families (two couples divorced during the study)	Coercive Parental Behaviour (60m) Fagot Interactive Code (Fagot & Hogan, 1986); proportion of time spent engaging in negative behaviours - physical restraint, criticism/verbal punishment, directives. Parental Instructional Behaviours (60m) Gauvain and Fagot's Problem Solving Code (Fagot & Gauvain, 1997; Gauvain & Fagot, 1987, 1995); frequency of cognitive guidance behaviours.	Unstructured, live home observation sessions (1 hour). Problem solving tasks (puzzle and route delivery task)	CBQ (60m) Attentional Focussing, Inhibitory Control, Low-intensity Pleasure, Perceptual Sensitivity (Goldsmith & Rothbart, 1991)	0.176*

Paper	Design (Time gap) N	Sample	Parenting Measure (Age)	Parenting Task	Effortful Control Measure (age)	Overall Effect Size (r)
Graziano, Keane and Calkins (2010)	L (42m) N=188	Oversampled children with externalising behaviour problems (CBCL)	Maternal Warmth/Positive Affect (24m) Sensitivity/Responsiveness (24m) Overcontrol/Intrusiveness (24m) Early Parenting Coding System (Winslow, Shaw Bruns & Kiebler, 1995)	"Tasks designed to elicit emotion regulation and mother-child interaction"	Behavioural (66m) Stroop task (animals and shapes, large/small)	0.270***
Hammond, Muller, Carpendale, Bibok and Liebermann-Finestone (2012)	L (12.1m) N=82	Community	Scaffolding (24.6m) 5 point scale, based of proportion of time spent consistent with definition of scaffolding from Wood, Bruner and Ross (1976).	Ring Puzzle Task (Carpendale 1999, Schmidt-Schonbein & Thiel 2010).	Conflict (36.7m) Bear-Alligator (Kochanska, Murray, Jacques, Koenig & Vandergeest, 1996) Reverse Categorisation (Carlson , Mandell & Williams, 2004)	0.050
Houck & LeCuyer-Maus (2004)	L (48m) N=78	Community	Maternal Limit Setting (12m) Prohibition Coding Scheme (Houck & LeCuyer, 1995, from Medvin & Speiker, 1985); time spent by mothers using different control strategies – commands, directions as commands, distractions, hold, imaginary distractions, meaning reconstruct, reasoning, sensitive follow, sensitive praise, sensitive soothe and physical no-touch.	Prevent child from touching or playing with a novel object	Delay of Gratification (60m) Self Imposed Delay Waiting Paradigm (Mischel, Ebbesen & Zeiss, 1972 ; Mischel, Shoda & Rodriguez, 1989; Shoda et al., 1990)	0.212
Hughes and Ensor (2006)	C N=127	Sample recruited in low-income neighbourhoods, and support groups for young or depressed mothers.	Harsh Parenting (28.6m) 11 item, 3-point Harsh parenting scale (Moffitt & E-Risk Study Team, 2002) Negative Control and Negative Affect scale from Parent-Child Interaction System (Deater-Deckard, Pylas and Petrill, 1997). Coding of alternate 30s video segments according to 6-point rating scale.	Structured home visit (data collection of Theory of Mind tasks) Free play and tidy-up.	Executive Function (28.6m) Spin the Pots (Gerstadt, Hong and Diamond, 1994) Trucks game (rule-switch) Baby Stroop Beads Working Memory task (Thorndike, Hagan and Sattler, 1986) Detour-Reaching Task (Hughes & Russell, 1993)	0.330***

Paper	Design (Time gap) N	Sample	Parenting Measure (Age)	Parenting Task	Effortful Control Measure (age)	Overall Effect Size (r)
Jennings, Sandberg, Kelley, Valdes, Yaggi, Abrew et al. (2008)	L (14.4) N=100	Half of mothers recruited from a psychiatric facility and had experienced depression since birth of the child.	Maternal Warmth (19.6m) Composite of maternal positive and negative affect, (Belsky, Youngblade, Rovine & Volling, 1991), rated every 30 second on a 4-point scale.	Teaching child how to work a difficult toy (shape sorter).	Behavioural (34.0m) Gift Task Whisper task Turtle and rabbit Tower task (Kochanska et al., 1996)	0.280**
Karreman et al., 2008	C N=89	Community	Positive Control (36m) Provision of structure, limit setting and sensitivity Negative Control (36m) Negativity and Investment Warmth (36m) Coparenting and Family Rating System (McHale, 1995). Three one-minute section of interaction observed and six dimensions rated according to a 7-point scale.	Play matching game, building game, reading a picture book, clean up.	Behavioural (36m) (Kochanska et al, 2000): Snack delay, Wrapped Gift, Gift-in-Bag, Tongue, Dinky Toys, Shapes Questionnaire (36m) CBQ Inhibitory Control (Goldsmith & Rothbart, 1991)	0.172
Kiff, Lengua and Bush (2011)	C N=196	Community	Warmth (113.8m) Negativity (113.8m) Guidance and structure (113.8m) Autonomy granting (113.8m) Global codes assigned according to 5-point scale (Cowan & Cowan, 1992, Lindahl and Malik, 2000).	Discuss child's day at school (neutral) and discuss attempt to resolve a recent conflict	Early Adolescent Temperament Questionnaire (113.8m) (EATQ; Capaldi and Rothbart, 1992) Attention regulation CBQ (113.8m) (Goldsmith & Rothbart, 1991) Inhibitory Control Combined parent and child report	0.100

Paper	Design (Time gap) N	Sample	Parenting Measure (Age)	Parenting Task	Effortful Control Measure (age)	Overall Effect Size (r)
Kochanska, Aksan, Prisco & Adams, 2008	L (36.6M) N=99	Community	Mutually Responsive Orientation (7.2m, 15.1m, 25.4m composite; Mean = 15.9m) (Aksan, Kochanska & Ortman, 2006) Rating of 16 (7m) or 17 (15m and 25m) items in each context on 5-point scale. Based on four theoretical components of MRO; co-ordinated routines, mutual co-operation, harmonious communication and emotional ambience.	Naturalist contexts eg play with toys, snack time, parent busy.	Behavioural (52.5m) Kochanska et al., (1996; 1997; 2000) <i>Delay of gratification</i> : Tongue, Snack Delay, Dinky Toys, Gift in a bag, Gift Wrap. <i>Slowing motor activity</i> : Telephone Poles, Walk-a-line-slowly, Turtle-and-Rabbit. <i>Go no-go tasks</i> : Red-Green Signs, Bird and Dragon. <i>Turn Taking</i> : Tower. <i>Stroop-like</i> (Carlson & Moses, 2001): Day-Night, Snow-grass	0.51***
Kochanska, Murray & Harlan (2000)	L (23.5m) N=112	Community	Maternal Responsiveness (8.9M) Time-sampled and event triggered coding (De Wolff & Van Ijzendoorn, 1997; Thompsen, 1998). Each 60s segment coded initially for child behaviour, maternal behaviour to each child-related event coded according to a 4-point scale.	Naturalistic contexts such as routine care, play, free time, toy cleanup.	Behavioural (32.4) <i>Delay</i> : Snack Delay, Tongue, Dinky Toys. <i>Slowing Motor Activity</i> : Walk-A-Line-Slowly, Turtle and Rabbit, Drawing activity. <i>Turn Taking</i> : Tower. <i>Stroop</i> : Shapes. <i>Lowering Voice</i> : Whisper	0.19*
Kraybill and Bell (2012)	L (39.1) N=56	Community	Maternal Positive Emotion (10.3m) 30s epochs rated on 4 point Likert scale, based on Calkins, Hungerford and Dedmon (2004)	Play with two specific toys.	Executive Function (49.4m) Pig/Bull task, based on Bear/Dragon (Carlson & Moses, 2001) Dimensional Change Card Sort Test (Zelazo, Frye & Rapus, 1996) Yes-No task (Wolfe & Bell, 2004, 2007), based on day-night task (Diamond, Prevor, Callender & Druin, 1997)	0.29*

Paper	Design (Time gap) N	Sample	Parenting Measure (Age)	Parenting Task	Effortful Control Measure (age)	Overall Effect Size (r)
Lavigne, Gouze, Hopkins, Bryant and LeBailly (2012)	C N=796	Community	Scaffolding (53.3m) Fifteen minute video observed and 5 factors rated on a 7-point scale: Supportive Presence, Respect for autonomy, Quality of assistance, Cognitive stimulation, Confidence, Hostility	Three Boxes Paradigm (NICHD ECRN 1999).	CBQ (53.3m) (Goldsmith & Rothbart, 1991) Attentional Focussing, Inhibitory Control. Behavioural (53.3m) NEPSY statue subtest (Korkman, Kirk & Kemp, 1997)	0.158***
Lengua, Honorado & Bush, 2007	C N=80	Community	Maternal warmth (36.6m): Positive affect and Interactiveness Scaffolding (36.6m): Responsiveness, Respect for autonomy Negative Affect (36.6m) Limit Setting (36.6m) Adapted from System for Coding Interactions and Family Functioning (SCIFF; Lindahl and Malik, 2000) and Parenting Style Ratings Manual (Cowan & Cowan, 1992). Maternal behaviours rated according to 5-point scale: Positive affect, Interactiveness, Responsiveness, Respect for autonomy, Limit Setting and Negativity/Negative Affect.	Restricted Play Unrestricted Free-Play LEGO-building task (from Kerig & Lindahl, 2001)	Behavioural (36.6m) Bear-Dragon (Kochanska et al., 1996). Day-Night (Gerstadt et al., 1994) Grass-Snow (Carlson & Moses, 2001) Butterfly (Go/no-go novel task) Gift Delay (Kochanska et al, 1996)	-0.003
Li-Grining, 2007	L (7.9m) N=439	Recruited in low-income neighbourhoods. Eligibility determined by SES factors eg ethnicity, income.	Child-Mother Connectedness (38.2, 54 M=46.1) 4 point scale, global rating of connectedness.	Puzzle Task - 4 puzzles of increasing difficulty (Chase-Lansdale, Brooks-Gun & Zamsky, 1989) adapted from Owen and Henderson (1988), Easterbrooks and Goldberg (1984), Sroufe, Matas and Rosenberg (1980)	Delay of Gratification (54m) Snack Delay, Gift Wrap (Kochanska et al, 1996) Executive Control (54m) Shapes task (Kochanska et al., 1997), Turtle-Rabbit task (Kochanska et al., 1996)	0.126**

Paper	Design (Time gap) N	Sample	Parenting Measure (Age)	Parenting Task	Effortful Control Measure (age)	Overall Effect Size (r)
Mintz et al. (2011)	L (33.7m) N=1363 (stats)	Community	Maternal Sensitivity (6m, 15m, 24m, 36m; M=20.3m) Sum of three 4-point global ratings of Sensitivity, Intrusiveness, Positive regard at 6m, 15m, and 24m. At 36m, sum of three 7-point ratings of maternal supportive presence, hostility, respect for autonomy. Standardised and averaged across time points.	Free play (6m) Play and problem-solving task (15m, 24m, 36m)	CBQ (54m) (Goldsmith & Rothbart, 1991) Attentional Focussing, Inhibitory Control	0.276***
Moilanen et al. (2010)	C N=731 (stats)	Screened for socioeconomic, family or child risk factors.	Parent Positive Behaviour Support (29.9m) Home observation for measurement of the environment scale (HOME) Involvement subscale (Caldwell & Bradley, 1978). Three statements rated on a binary scale. Relationship Process Code (RPC; Jabson, Dishion, Gardner & Burton, 1983). Duration proportions of positive behaviour support and engagement. Coder Impressions Inventory (COIMP), proactive parenting index, ratings of tendency to anticipate potential problems. Scales were standardised and summed to create composite. Harsh Parenting (29.9m) Five items from the COIMP (provision of developmentally inappropriate reasons, displays of anger or annoyance, criticizing/blaming child, physical discipline, ignoring/rejecting child giving messages about child's worthlessness). Three duration proportions from the RPC (negative verbal, directive and physical behaviour). Standardised and summed to create a composite.	Structured home visit. Two hour visit where questionnaires and interactive tasks (data collection) were completed.	CBQ (29.9m) (Goldsmith & Rothbart, 1991) Inhibitory Control	0.0801*

Paper	Design (Time gap) N	Sample	Parenting Measure (Age)	Parenting Task	Effortful Control Measure (age)	Overall Effect Size (r)
Olson, Bates, Sandy and Schilling (2002)	L (90m) N=89	Community	Close contact (6m) - proximate vocalisation – sweet musical quality, affectionate touch, bounce/jiggle/rock, put to shoulder, smile, hold. Object Stimulation (6m) - offer toy, offer and demonstrate toy, return object to baby. Behavioural event recording using coding manual of maternal behaviours.	Home, unstructured naturalistic observation; two three-hour visits.	Behavioural (96m) Matching Family Figures Task (Kagan, Rosman, Day, Albert & Phillips, 1964) Draw a Star Slowly, Milich and Kramer 1984)	0.153
Razza, Martin and Brooks-Gun (2010)	L (24m) N=1046 (Poor: N=561 Near Poor: N=485)	Oversampled children born to unmarried parents.	Maternal warmth (36m) Maternal lack of hostility (36m) Four dichotomous rating items for each scale. Drawn from the HOME (Caldwell and Bradley, 1984) and Homelife Interview (Leventhal, Selner-O'Hagan, Brooks-Gunn, Bingenheimer & Earls, 2004).	Home visit structured around data collection (parent interview and child assessment).	Lack of impulsivity (60m) Incorrect responses, score reversed. Leiter International Performance Scale-Revised, attention sustained task (Roid & Miller, 1997).	Poor: -0.020 Near Poor: 0.040
Rhoades, Greenberg, Lanza & Blair, 2011	L (29m) N=890 (AA: N=359 Cauc. N=531)	Recruited from locations with high poverty rates, oversampling of low income and African American (AA) families.	Maternal positive engagement (7m) mean score for detachment, positive regard, animation and stimulation for development subscales. Maternal negative intrusiveness (7m) mean score for sensitivity, intrusiveness and negative regard subscales. Seven subscales rated on 5-point scale and aggregated according to Garrett-Peters, Mills-Koonce, Adkins, Vernon-Feagans & Cox (2008).	Ten minute free play, given a set of toys. (Cox, Paley, Payne & Burchinal, 1999; NICHD ECCRN, 1999)	Executive Function (36m) Simon Task (Gerardi-Caulton, 2000; Diamond, Barnett, Thomas and Munros, 2007). 'Working memory' task with 'overcoming interference' component (novel). Flexible Item Selection Task (Jacques and Zelazo, 2001).	AA: 0.121* Cauc.: 0.180***
Sheese, Voelker, Rothbart and Posner (2007)	C N=45	Community	High/Low quality parenting (18m-21m; 19.5m midpoint) Rating on on 7-point scale: Supportive Presence, Respect for autonomy, Stimulation of Cognitive Development, Hostility, Confidence. Adapted from NICHD ECRN (1993)	Free play	ECBQ (18m-21m; 19.5m midpoint) (Putnam et al., 2006) Attentional focusing Attentional shifting Inhibitory Control	0.080

Paper	Design (Time gap) N	Sample	Parenting Measure (Age)	Parenting Task	Effortful Control Measure (age)	Overall Effect Size (r)
Spinrad et al. (2007)	L (12m) N=215- 242	Community	Sensitivity (17.8m) Rated on a 4-point scale every 15s (freeplay) and 30s (puzzle task), based on being appropriately attentive and responsive to child's affect, interests and abilities. Warmth (17.8m) One rating on a 5-point scale made every thirty seconds. Based on levels of friendliness, closeness, encouragement and positive affect.	Free play (with toys provided) and teaching task (2 difficult puzzles) Teaching task only.	ECBQ (29.8m) (Goldsmith & Rothbart, 1991) <i>Attentional Control</i> : Attention-Focussing, Attention-Shifting <i>Inhibitory Control</i> : Inhibitory Control Behavioural (29.8m) Delay of gratification	0.208**
van Aken, Juner, Verhoeven, van Aken and Dekovic (2007)	C N=117	Community	Lack of Sensitivity (16.9m) Supportive presence, Clarity of instruction, Sensitivity and Confidence dimensions. Negative Control (16.9m) Hostility and Intrusiveness dimensions. Six dimensions rated on a 7-point scale; Erikson scales, 1990 revision (Egeland, Erickson, Clemenhagen-Moon, Hiester & Korfmacher, 1990; Erickson, Sroufe & Egeland, 1985).	Thirteen minute structured play session; play with blocks, read a picture book, clean up	ECBQ (16.9m) (Goldsmith & Rothbart, 1991) Inhibitory Control	-0.035
Von der Lippe, Eilertsen, Hartmann and Killen, (2010)	L (71.5m) N=40	Community	Maternal sensitivity (6-7m, midpoint = 6.5m) Maternal behaviours (facial and vocal expressions, position and body contact, affection, contingent turn-taking, control and choice of activity) rated as sensitive, controlling or passive using the Care Index (Crittenden, 2001).	Freeplay with toys provided by the researchers.	Executive Function (72m-84m, midpoint=78m) Running Horses Game Test (Hartmann & Haavind, 1981) assessing inhibitory control, working memory and cognitive flexibility.	0.280

Table 3:
Moderator Variables for Study Set

Paper	Site	N	Design	Time Gap (m)	Sample	Con.	Parenting Task	Method.	Loc.	EC Measure	Sex (% male)	SES	Ethnicity	Maternal age	% Two Parent Families
Bernier et al. (2010)	Canada	80	L	13.4	Com.	E	U	O	H	B	45.0	MC	81.3	28.3	91.3
Cipriano & Stifter (2010)	US	66	L	29.9	Com.	E	U	E	H						
						S	S	E	L	B	52.8	MC	100	29.7	NS
Eiden et al. (2007)	US	272	L	12	HR	E	U	O	L	B	51.1	MC	94	29.4	100
Eisenberg et al. (2001)	US	202	C	0	HR	E	S	O	L	Q	55.9	MC	76	NS	NS
Eisenberg et al. (2003)	US	153	C	0	Com.	E	S	O	L	B					
										Q	49.7	MC	78	NS	72
Feldman et al. (1999)	Israel	33	L	21	Com.	E	U	E	L	B	51.5	MC	Israeli	25.1	100
						S	S	O	L						
Gartstein and Fagot (2003)	US	159	L	21	Com.	S	U	E	H	Q	47.8	MC	92.6	27.3	100
						S	S	E	L						
Graziano et al. (2010)	US	333	C	0	HR	E	S	O	L	B	48.3	MC	67	NS	77
Hammond et al. (2012)	Canada	82	L	12.1	Com.	S	S	O	L	B	53.7	MC	88	NS	88
Houck & LeCuyer-Maus (2004)	US	78	L	48	C	S	S	E	L	B	67	MC	86	24.7	70
Hughes & Ensor (2006)	UK	127	C	0	HR	E	S	O	Bo	B	59.8	D	NS	NS	NS
Jennings et al. (2008)	US	100	L	14.4	HR	E	S	O	H	B	52	MC	91	NS	88
Karreman et al. (2008)	Netherlands	89	C	0	Com.	E	S	O	H	B	50.6	MC	99	31.5	100
						S	S	O	H	Q					
Kiff, Lengua and Bush (2011)	US	196	C	0	Com.	E	S	O	H	Q	44	MC	70	NS	70
						S	S	O	H						
Kochanska et al. (2008)	US	99	L	36.6	Com.	E	Bo	O	Bo	B	49.5	MC	80	30.2	NS
Kochanska et al. (2000)	US	106	L	23.5	Com.	E	U	E	L	B	50	MC	NS	NS	NS
Kraybill & Bell (2012)	US	56	L	39.8	Com.	E	S	O	L	B	53.6	MC	91	31.0	NS
Lavigne et al. (2012)	US	796	C	0	Com.	S	S	O	H	B	49.1	MC	54.4	NS	78.1
										Q					
Lengua et al. (2007)	US	80	C	0	Com.	E	Bo	O	L	B	54	MC	71	NS	76
						S	Bo	O	L						
Li-Grining (2007)	US	439	L	7.9	HR	E	S	O	H	B	55	D	5	26.4	35
Mintz et al. (2011)	US	1364	L	33.7	Com.	E	S	O	Bo	Q	51.7	MC	80.4	NS	85

Paper	Site	N	Design	Time Gap (m)	Sample	Con.	Parenting Task	Method	Loc.	EC Measure	Sex (% male)	SES	Ethnicity	Maternal age	% Two Parent Families
Moilanen et al. (2010)	US	731	C	0	HR	S	S	O	H	Q	51	D	50.1	NS	58
Olson et al. (2002)	US	89	L	90	Com.	E	U	E	H	B	56	MC	NS	24.5	NS
Razza et al. (2010)	US	1046	L	24	HR	E	S	O	H	B	51.6	D	14.2	NS	41
Rhoades et al. (2011)	US	890	L	29	HR	E	S	O	H	B	NS	D	60	25.7	33.1
Sheese et al (2007)	US	45	C	0	Com.	Bo	U	O	L	Q	64.4	MC	85	NS	NS
Spinrad et al. (2007)	US	215-242	L	12	Com.	E	S	O	L	Q	55.1	MC	58	NS	85
van Aken et al. (2007)	Netherlands	117	C	0	Com.	E	S	O	H	Q	100	MC	NS	NS	97
Von der Lippe et al. (2010)	Norway	40	L	71.5	Com.	E	S	O	H	B	50	MC	100	32.0	NS

N: Sample size

Design: Study design - Longitudinal (L) or Concurrent (C)

Time Gap: gap in time between measure of parenting and measure of effortful control (months),

Sample: Community (C) or High Risk (HR)

Parenting:

Con.=Construct – Emotional (E), Structure (S) or Both (Bo); Task – Structured (S), Unstructured (U) or Both (Bo), Method (of assessment)– Observer rating (O) or Event Coding (E), Loc. (Location) – Home (H), Laboratory (L) or Both (Bo)

EC Measure: Effortful control measure – Behavioural (B) or Questionnaire (Q)

SES: Socioeconomic Status – Middle Class (MC) or Disadvantaged (D)

The association between quality of parenting and effortful control.

The point estimate for overall effect size for the 31 independent samples, drawn from 29 studies including N=7921 participants was small but significant ($r=.17$, $p<.001$, 95% CI .12-.21). Higher quality parenting was associated with higher levels of effortful control. There was evidence of significant heterogeneity within the sample ($Q=90.6$, $p<.001$).

Is there evidence of publication bias?

The funnel plot created using the 'trim-and-fill' method (Duval & Tweedie, 2000a, 2000b) is shown in Figure 2.

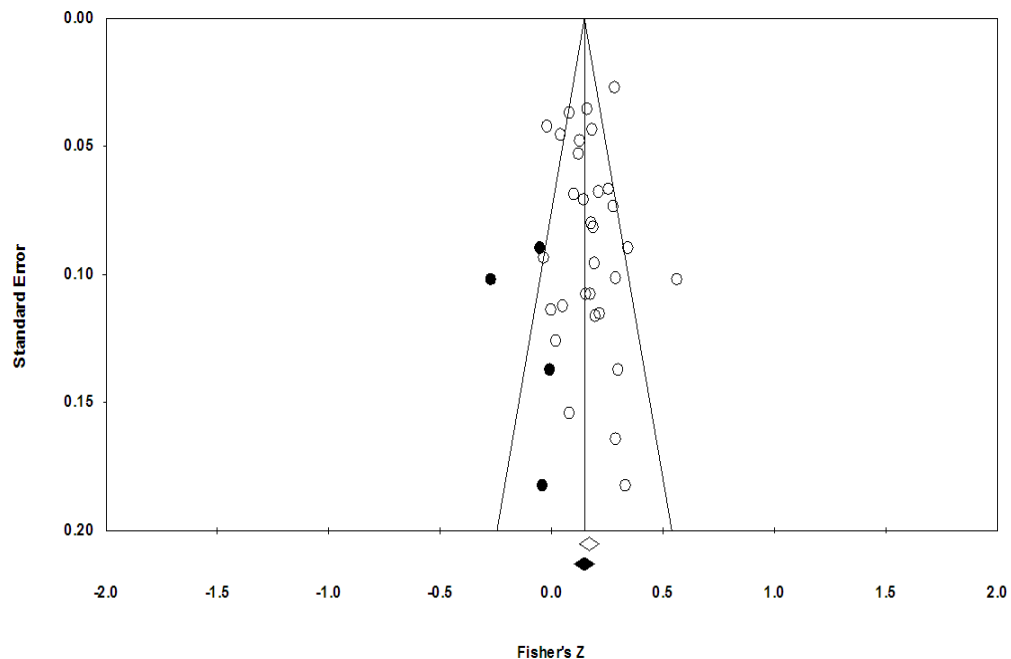


Figure 2: Funnel Plot of Fisher's Z by Standard Error Assessing Publication Bias.

Only four studies were trimmed and filled, with a resulting point estimate of combined effect size of $r=.15$ (95%CI: 0.130, 0.173). The failsafe number of studies reporting null results which would be required to reduce the effect to non-significance was 1339. This exceeds Rosenthal's criterion of 165 ($5k+10$) and hence indicates that the effect size is likely to be robust and unaffected by the 'file-drawer problem.'

Moderator Analysis

Since the total study set was heterogeneous, moderators which might account for this variability were investigated (see Table 4).

Table 4:

Moderator Analysis

	k	N	r	95% CI	Homogeneity Q	Contrast Q	Contrast p
Overall	31	7921	.17***	.12 - .21	90.6***		
Parenting construct							
Emotion	21	5578	.19***	.14 - .25	77.8***		
Structure	9	2295	.11***	.057 - .16	10.6	4.25	0.039
Effortful Control Measure							
Behavioural	19	3763	.19***	.12 - .25	57.4***		
Questionnaire	12	4158	.16***	.097 - .21	29.7**	0.50	0.478
Study Design							
Concurrent	11	2713	.13***	.082 - .18	13.9		
Longitudinal	20	5205	.19***	.13 - .25	72.08***	2.135	0.144
Study location							
Non-US	7	565	.17**	.058 - .29	11.0		
US	24	7353	.16***	.12 - .21	79.6***	0.023	0.880
Sample							
Community	20	3968	.18***	.13 - .23	40.8**		
High Risk	11	3950	.15***	.087 - .21	34.9***	0.64	0.424
Socioeconomic Status							
Disadvantaged	7	3233	.11**	.042 - .17	21.3**		
Middle Class	24	4685	.19***	.15 - .24	43.6**	4.16	0.041
Parenting assessment method							
Event Coding	6	537	.17***	.086 - .25	2.45		
Observer Rating	24	7304	.17***	.12 - .21	88.0***	0.012	0.914
Parenting assessment task							
Both	4	415	.23*	.010 – .43	15.3**		
Structured	22	6997	.15***	.10 - .20	69.5***		
Unstructured	5	506	.21***	.12 - .29	1.92	1.79	0.408
Parenting Assessment Location							
Both	4	1748	.29***	.24 - .33	9.51*		
Home	14	4628	.10***	.077 - .13	24.9*		
Lab	13	1542	.19***	.14 - .23	10.9	12.8	0.002

*p< .05. **p<.01. ***p<.001

A significantly larger effect size ($Q=4.25$, $p=.039$) was found for studies which investigated emotional aspects of parenting ($k=21$, $r=.19$, $p<.001$), compared to studies investigating aspects of parenting related to structure, limit-setting and scaffolding ($k=9$, $r=.11$, $p<.001$). In this analysis, one study was excluded because the effect size was calculated for both aspects of parenting. For the four studies which reported effect sizes for both emotional and structural aspects of parenting, only the effect sizes related to structural aspects were included, in order to ensure a sufficiently large set of studies reporting effect sizes for structural aspects of parenting.

There were no significant differences in effect sizes for studies assessing effortful control using behavioural compared to questionnaire methods ($Q=0.50$, $p=.478$). There were also no significant differences between longitudinal and concurrent studies ($Q=2.13$, $p=.144$), although there was substantially more heterogeneity amongst longitudinal studies (Homogeneity $Q=72.8$, $P<.001$). There were also no significant differences between effect sizes for studies conducted in the USA compared to studies conducted elsewhere ($Q=0.023$, $p=.880$) although again substantially more heterogeneity was found in studies conducted in the USA (Homogeneity $Q=79.6$, $p<.001$).

In terms of sample, there were no significant differences between effect sizes for Community ($k=20$) versus High Risk ($k=11$) samples ($Q=0.64$, $p=.424$), with significant heterogeneity in both (Homogeneity $Q=4.08$, $p<.01$ and Homogeneity $Q=34.9$, $p<.001$ respectively). There was, however, a significant difference for effect sizes with respect to the socioeconomic status of the study samples. The point estimate of effect size for studies conducted with middle class samples ($k=24$, $r=0.19$, $p<.001$) was significantly higher ($Q=4.16$, $p=.041$) than the point estimate for studies conducted with socioeconomically disadvantaged groups ($k=7$, $r=.11$, $p<.01$).

With respect to moderators relating to the assessment of parenting, there was no significant difference in point estimate of effect sizes for studies using event coding ($k=6$) compared to observer ratings ($k=24$) as the method of rating parenting ($Q=.012$, $p=.914$). The comparison of studies according to parenting assessment method did not include one study for which the effect size reported had included both. There was also no significant difference between estimates of point effect size for studies where parenting assessments used structured tasks ($k=22$), unstructured tasks ($k=5$) or a combination of the two ($k=4$; $Q=1.79$, $p=.408$). Studies using both structured and unstructured assessments, or only structured assessments, showed significant heterogeneity ($k=4$, $Q=15.3$, $p<.01$ and $k=22$, $Q=69.5$, $p<.001$) whereas there was no significant heterogeneity amongst studies using unstructured assessments ($k=5$, $Q=1.92$).

There was a significant difference between the point estimate of effect size ($Q=12.79$, $p=0.002$) depending on where parenting was assessed. The association was lowest for studies where parenting was assessed at home ($k=14$, $r=.11$, $p<.001$), greater when assessments were conducted in the laboratory ($k=13$, $r=.19$, $p<.001$) and highest when assessments were conducted in both locations ($k=4$, $r=.29$, $p<.001$).

Meta-Regression Analysis

Meta-regressions were calculated for continuous moderator variables using the standard mean differences shown in Table 5.

Table 5:

Effect Sizes and Moderator values included in Meta-Regression

Paper	Effect Size		Time Gap between measures (m)	Covariates included in meta-regression				
	SMD	Standard Error		Age EC Assessed (m)	Age Parenting Assessed (m)	Sex (% male)	% Two parent families	Ethnicity (% Caucasian)
Bernier et al. (2010)	0.395	0.238	13.4	26.3	12.9	45	91.3	81.3
Cipriano and Stifter (2010)	0.052	0.269	29.9	54	24.1	52.8	-	100
Eiden et al. (2007)	0.517	0.138	12	36	24	51.1	100	94
Eisenberg et al. (2001)	0.289	0.143	0	73	73	55.9	-	76
Eisenberg et al. (2003)	0.377	0.166	0	112.8	112.8	49.7	72	78
Feldman et al. (1999)	0.676	0.385	21	24.3	3.3	51.5	100	-
Gartstein and Fagot (2003)	0.358	0.163	0	60	60	47.8	100	92.6
Graziano et al. (2010)	0.561	0.153	42	66	24	48.3	77	67
Hammond et al. (2012)	0.100	0.225	12.1	36.7	24.6	53.7	88	88
Houck & LeCuyer-Maus (2004)	0.434	0.236	48	60	12	67	70	86
Hughes and Ensor (2006)	0.699	0.190	0	28.6	28.6	59.8	-	-
Jennings et al. (2008)	0.583	0.212	14.4	34	19.6	52	88	91
Karreman et al. (2008)	0.352	0.221	0	36	36	50.6	100	99
Kiff, Lengua and Bush (2011)	0.202	0.139	0	113.8	113.8	43.5	70	70
Kochanska et al. (2008)	1.186	0.237	36.6	52.5	15.9	49.5	-	80
Kochanska et al. (2000)	0.387	0.195	23.5	32.4	8.9	50	-	-
Kraybill & Bell (2012)	0.606	0.287	39.8	49.4	10.3	53.6	-	91
Lavigne et al. (2012)	0.320	0.072	0	53.3	53.3	49.1	78.1	54.4
Lengua et al. (2007)	-0.005	0.228	0	36.6	36.6	54	76	71

Paper	Effect Size		Time Gap between measures (m)	Covariates included in meta-regression				
	SMD	Standard Error		Age EC Assessed (m)	Age Parenting Assessed (m)	Sex (% male)	% Two parent families	Ethnicity (% Caucasian)
Li-Grining (2007)	0.254	0.097	7.9	54	46.1	55	35	5
Mintz et al. (2011)	0.574	0.056	33.7	54	20.3	51.7	85	80.4
Moilanen et al. (2010)	0.161	0.074	0	29.9	29.9	51	58	50.1
Olson et al. (2002)	0.312	0.220	90	96	6	56	-	-
Razza et al. (2010): Near Poor	0.161	0.092	24	60	36	51.34	41	18.97
Razza et al. (2010): Poor	0.015	0.085	24	60	36	51.87	41	10.16
Rhoades et al. (2011): AA	0.244	0.107	29	36	7	-	40.8	0
Rhoades et al. (2011): Caucasian	0.366	0.088	29	36	7	-	85.1	100
Sheese et al (2007)	0.161	0.310	0	19.5	19.5	64.4	-	85
Spinrad et al. (2007)	0.426	0.139	12	29.8	17.8	55.1	85	58
van Aken et al. (2007)	-0.070	0.187	0	16.9	16.9	100	97	-
Von der Lippe et al. (2010)	0.583	0.342	71.5	78	6.5	50	-	100

SMD: Standardised Mean Difference, AA: African American

The results of the meta-regression analysis are shown in Table 6.

Table 6:

Meta-Regression Results

Covariate	K	B (SE)	t (p)	τ^2	I^2_{res}	Adj. R^2
Time Gap (all studies)	31	.002 (.002)	1.62 (.116)	.022	57.2%	9.78%
Time Gap (longitudinal)	20	.003 (.003)	0.80 (.434)	.032	66.7%	0.04%
Age EC Assessed	31	-.000 (.002)	-0.04 (.969)	.026	62.9%	-6.49%
Age Parenting Assessed	31	-.002 (.001)	-1.14 (.265)	.024	60.5%	0.91%
Sex	29	-.007 (.005)	-1.49 (.148)	.028	63.5%	3.15%
Cohabiting	22	.005 (.002)	2.81 (.011)	.009	41.3%	51.8%
Ethnicity	26	.003 (.001)	2.82 (.010)	.011	45.7%	52.3%
<i>Cohabiting and Ethnicity</i>				.007	31.7%	61.3%
Cohabiting	20	.001 (.003)	0.23 (.818)			
Ethnicity	20	.006 (.005)	1.42 (.173)			

B (SE): Unstandardised regression coefficient (Standard Error)

t (p): test of variance estimated using Knapp–Hartung variance estimator

Adjusted R^2 : Proportion of between study variance which can be explained by covariate.

τ^2 : between studies variance

I^2_{res} : proportion of residual variation in sample due to heterogeneity (rather than sampling variability)

The time gap between assessment of parenting and assessment of effortful control did not yield significant regression weight. This was the case regardless of whether data with a time gap of 0 months was included (slope =.002, $p=.116$) or not (slope =.003, $p=.434$). Regression analyses of age at which effortful control and parenting were assessed and the sex ratio of the sample were also not significant.

The meta-regression analysis with percentage of families cohabiting as a predictor was significant (slope =.005, $p=.011$). This variable accounted for 51.8% of the variance between studies, with studies including families with more two-parent households reporting larger effect sizes. A ‘bubble plot’ of percentage of two-parent families in each study against the study estimate of effect size (standard mean difference), and the regression line is shown in Figure 3. The size of the data point corresponds to the precision of the study (equal to the inverse of the within study variance).

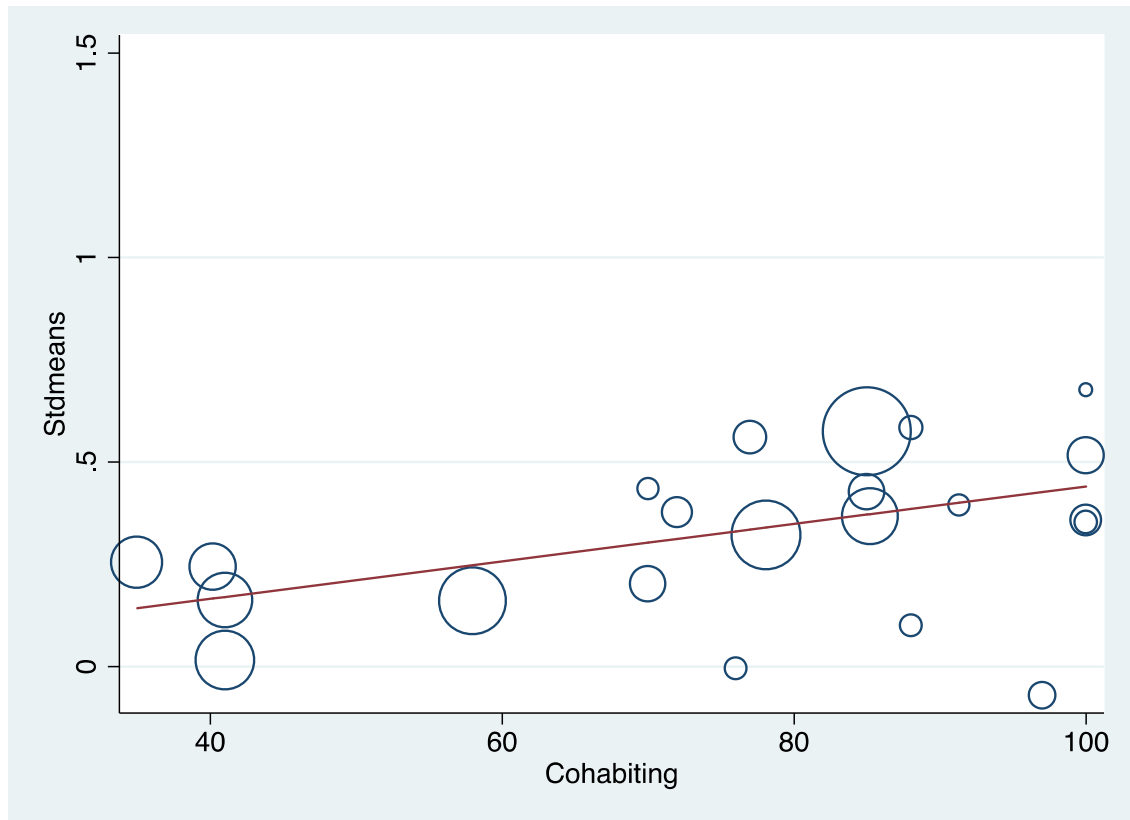


Figure 3: 'Bubble Plot' of % Families with Two Parents Cohabiting against Standard Mean Difference Meta-Regression (k=22).

The meta-regression analysis conducted with ethnicity (the percentage of Caucasian children and families in each study) was also significant (slope =.003, $p=.010$). The percentage Caucasian children and families accounted for 52% of between study variation, with studies with a higher proportion of Caucasian children and families reporting greater effect sizes. Figure 4 shows the 'bubble plot' of percentage Caucasian families in the study against effect sizes and the accompanying regression line.

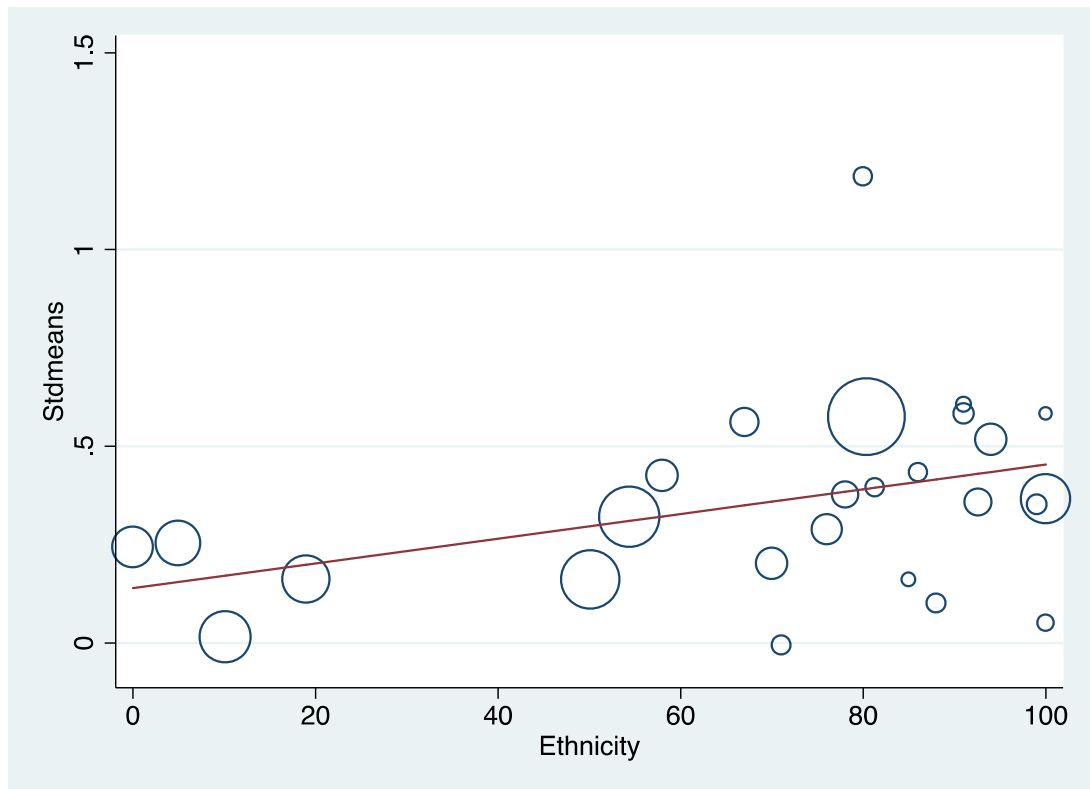


Figure 4: 'Bubble Plot' of % Caucasian Families Against Standard Mean Difference Meta-Regression (k=26).

The point at 80% Caucasian, SMD=1.19 (which appears somewhat outlying) is drawn from Kochanska et al. (2008) and does not appear on the previous 'bubble plot' as no data regarding % of parents cohabiting was reported. The regression remained significant when this point was removed.

A meta-regression model including both significant covariates was significant ($F_{(2,17)} = 5.95$, $p = .011$) and accounted for 61% of between study variability. Neither the percentage of two-parent households, nor percentage of Caucasian children and families were independently significant ($p = .818$, $p = .173$ respectively) implying confounding of these two measures.

Discussion

Meta-Analytic Findings

This review provides the first meta-analytic estimates of the relationship between early quality of care and later effortful control. The results revealed a small but highly significant correlation between measures of observed maternal parenting and measures of child effortful control ($r=.17$, $p<.001$). The 95% Confidence Interval (.12-.21) does not include zero. This effect was calculated using data from nearly 8,000 children across 29 studies reporting a total of 31 independent data sets and provides convincing evidence for a significant association between maternal parenting and child effortful control.

This figure is likely to be a robust estimate, since the outcome of the meta-analysis does not appear to have been substantially affected by data censoring or the 'file-drawer problem' (Rosenthal, 1979). The point estimate of the effect size remained significant after the 'trim-and-fill analysis' and the failsafe number of unpublished studies needed to reduce the effect size to below significance was 1339. Many of the studies included in the meta-analysis did not have the analysis of the relationship between parenting and effortful control as their primary aim (e.g. Eiden et al., 2007; Lavigne et al., 2012; Mintz et al., 2011). This may well have ensured that studies identifying no significant relationship between parenting and effortful control were nevertheless published, since this was not the primary aim of the research, hence reducing bias in study findings toward significant results.

The significant association identified is consistent with conclusions reported in narrative reviews of the literature (Kiff, Lengua & Zalewski, 2011; Eisenberg et al., 2013 pp 263-283) which identify the importance of socialisation and environmental influence on the development of effortful control. The finding also adds weight to theories proposing the role of parenting in the development of effortful control (Kopp, 1982, Fonagy & Target, 2002). These theories both propose that effortful control develops within the context of the parent-child relationship. Parent-child interactions

of higher quality may therefore better support the development of effortful control, hence resulting in the correlation noted.

There are a number of important caveats to this finding. Firstly, whilst it is tempting to conclude that the correlational relationship between parenting and child effortful control indicates that parental behaviours play a causal role in the development of effortful control, this cannot be concluded from the results of this meta-analysis alone. The result provides good evidence for an association, relevant to the empirical investigation of causal relationships and the development of theories relating to this, but does not, in itself, provide any explanation for the mechanisms through which the association may have arisen.

Secondly, the overall meta-analysis indicated substantial heterogeneity of effect sizes ($Q=90.6$, $p<.001$). The estimate of overall effect size thus represents an average across a diverse sample of studies which may well include many moderating factors affecting the extent of the association.

Thirdly, this meta-analysis focused exclusively on maternal parenting behaviours, since insufficient studies investigating paternal (or secondary caregiver) behaviours were identified. There are three implications of this, the first relating to this study and two to the wider literature. With respect to this study, there has been an implicit assumption that mothers are the primary caregiver (and hence primary socialising influence) for their child. This is unlikely to be consistently the case for all the mother-child dyads included in the analysis and hence represents a potential source of heterogeneity. Secondly, this assumption is also clearly the case for the wider literature, and it is frequently not reported whether the mother is the child's primary caregiver. This again may result in heterogeneity in effects found, and a lack of clarity as to whether any identified effects are a consequence of the maternal relationship specifically, or the relationship with primary caregiver. Finally, there is clearly a gap in the literature pertaining to the role of the paternal relationship,

paternal behaviours and the role of secondary-caregivers in the development of effortful control.

The fourth and final caveat relates to magnitude of the effect size. Cohen's (1977) convention is to describe the magnitude of the point estimate of effect size identified here ($r=.166$, $p<.001$) as 'small.' However, McCartney and Rosenthal (2000) argue against rigid application of these descriptions which could thereby result in erroneously dismissing so-called 'small' effects as trivial. They note that 'large' effect sizes are rarely found and many factors, beyond the 'actual' degree of association to be identified, can influence effects size: research design and methodology and measurement precision and accuracy.

McCartney and Rosenthal (2000) therefore recommend evaluating findings in the context of the existing empirical literature. The meta-analysis conducted by Karreman et al. (2006), investigating the association between parenting behaviour and self-regulation (a concept related to, but not synonymous with, effortful control) provides a good basis for comparison. This study investigated the relationship between self-regulation overall, as well as the constituent abilities of emotion regulation, compliance and inhibition. Parenting is also defined differently by Karreman et al. (2006), with three dimensions identified. The first, positive control is described as relating to guidance and teaching and may thus be considered similar to the 'structure' parenting construct in the current review. The second, negative control, is defined as power assertive control including anger and harshness and the third dimension, responsiveness, is described as comprising warmth, sensitivity and positive affect. Together negative control and responsiveness might be considered equivalent to the emotional aspects of parenting investigated in the current study.

Overall, the authors found small but significant associations between self-regulation and parental 'positive control' ($r=.08$, $p<.05$, $k=31$, $N=1910$) and 'negative control,' ($r=-.14$, $p<.01$, $k=26$, $N=2290$) but not 'responsiveness' ($r=.03$ ns, $k=19$, $N=2248$); (Karreman et al., 2006). The effect sizes for positive and negative control

are in the expected direction, although smaller than the overall findings of the current meta-analysis. The difference between the two also appears to correspond with findings of the current study, that emotional aspects of parenting are more associated with outcomes than those relating to structure, guidance and teaching. It is difficult, however, to reconcile the lack of association with maternal responsiveness and self-regulation identified. It is likely that the lack of specificity of the term self-regulation led to greater variability in the constructs investigated in the included samples which may have served to reduce the magnitude of the overall effects identified. It is also of note that the analyses of Karreman et al. (2006) are based on a substantially smaller number of children.

Further Findings: Moderators

Parenting Construct

A key potential moderator of the relationship between parenting and effortful control related to the theoretical distinction between emotional and limit-setting aspects of parenting. The point estimate of effect size was significantly higher for emotional aspects of parenting than those relating to limit-setting and scaffolding ($Q=4.25$, $p=.039$). Again, this is consistent with Kopp's (1982) theory which identified parental sensitivity as important in supporting the development of effortful control. Since maternal sensitivity is significantly associated with attachment security (De Wolff & van Ijzendoorn, 1997), this finding is also consistent with Fonagy and Target's (2002) theory.

There remained substantial heterogeneity amongst the studies investigating emotional aspects of parenting ($Q=77.8$, $p<.001$). This may well reflect the substantial variation in parenting constructs and behaviours amongst studies included in this category. The methodological decision was taken that given the variability in the constructs used in the study set, and in the definitions of these constructs reported, further classification would not be reliable, accurate or feasible.

Further empirical investigation into whether these fine-grained distinctions, for example between maternal warmth and maternal sensitivity, are differently related to the development of effortful control would further our knowledge of the association and possible causal mechanisms.

Despite being significantly smaller, the association between aspects of parenting relating to structure, limit-setting and scaffolding and effortful control remained significant ($r=0.11$, $p<.001$). It is conceivable that in the case of parental limit-setting, effects of individual variation in effortful control are more likely to directly impact and elicit parenting behaviour. The reduced effect size may therefore be a consequence of this more complex relationship between the two factors. Despite the heterogeneity of parenting constructs and behaviours which included both limit-setting and scaffolding, the effect sizes for this category were not significantly heterogeneous ($Q=10.6$). Whilst this is interesting, since different associations might be expected for these constructs, this lack of heterogeneity may simply be a reflection of the small number of studies in the category ($k=9$).

Demographic Moderators

The effect size estimate was also found to be significantly higher ($Q=4.16$, $P=.041$) for samples of middle class families ($r=.19$, $p<.001$) compared to socioeconomically disadvantaged families ($r=.11$, $p<.01$). This is consistent with the notion that socio-economic status is an important factor in the development of effortful control (Lengua et al., 2008), executive attention (Mezzacappa, 2004) and executive functions (Hackman & Farah, 2009). Indeed, further it implies that these demographic factors may be of greater significance than parenting, since these results indicate that parenting exerts less influence on the development of effortful control in high risk circumstances. The results may also indicate that in high risk context there are other, as yet unknown, factors that exert the greatest influence on the development of effortful control. Since the effect size remained significant in

studies of families at socioeconomic disadvantage, however, parenting clearly remains associated with effortful control, even in the presence of psychosocial stressors.

In contrast to the effect of socioeconomic status, there were no significant differences ($Q=0.64$, $p=.424$) between estimates of effect size for community studies ($r=.180$, $p<.001$) and those recruiting from high-risk samples ($r=.15$, $p<.001$). This is somewhat counterintuitive, since all of the studies categorised as investigating families at socioeconomic disadvantage were also coded as having recruited a high risk sample. It is therefore interesting that the moderation effect does not persist.

In addition to the moderation analysis, meta-regression also indicated a significant relationship between the overall effect size estimate and ethnicity (slope $=.003$, $p=.010$) and the percentage of families cohabiting (slope $=.005$, $p=.011$). The point estimate of the association between effortful control and parenting was greatest in studies with the highest proportion of people of Caucasian origin and household where two adults were cohabiting. The regression model for these factors together was significant ($F_{(2,17)}=5.95$, $p=.011$), with these factors together accounting for 61.3% of between-study variability. This analysis also showed that the two factors were not independently significant, thus representing a conflation of one underlying factor affecting the magnitude of the relationship found between parenting and effortful control.

Together with the greater effect size for community samples compared to socioeconomically disadvantaged groups, these findings again indicate the important role of demographic/socioeconomic factors. The role of parenting in the development of effortful control appears to be consistently lower in the context of other risk factors. This may indicate the role of other factors not investigated in the current study or suggest a differential susceptibility (Belsky, 2005); children at socioeconomic disadvantage seem to benefit less from higher quality parenting than those children not exposed to these risk factors.

Turning to the effect of gender (proportion of boys in the sample), no significant slope was found (slope=-.007, $p=.148$). This may well have occurred because the proportion of boys in the study was very close to 50% in all but two studies. Sheese et al (2007) reported a sample comprised of 64.4% boys, however since the full sample size was only 45 this is likely to be of limited utility. The other paper to report a proportion of boys which deviated from an approximately 50:50 ratio was van Aken et al. (2007), which investigated a sample comprised entirely of boys ($N=117$).

An obvious limitation of the procedures used to evaluate the potential moderating effect of socioeconomic, risk and demographic factors is where studies were allocated to one of only two categories. Whilst this afforded the greatest degree of reliability in coding, the method is not entirely precise and in addition substantial detail may well have been lost. For example, many of the studies categorised as a 'community' study may well have included a proportion of individuals at socioeconomic disadvantage. The imprecise nature of this categorisation, as well as limited numbers of studies investigating risk factors, may have reduced the sensitivity and power of the meta-analysis to detect effects, and further empirical evaluation would be beneficial.

Two issues of data reporting impacted on the coding process of the meta-analysis and hence may have impacted the investigation into the effects of moderators on study effect size. Firstly, the means of assessing and reporting socioeconomic status and ethnicity varied greatly. These variations substantially reduced the comparability of sample characteristics between studies, and limited the possible breadth of moderator codes. Socioeconomic status was evaluated using annual income (which varies, in amounts and relative value, with the passing of time and between countries), Hollingshead Indices and income status relative to Federal Poverty Guidelines, and reported as a mean for the full sample, or the proportion of people within brackets/categories of income or socioeconomic status. Similarly, with

respect to ethnicity the most frequently available and consistently reported information is the proportion of children classified as 'white,' and there is inconsistency in whether it is child or parental ethnicity reported.

Secondly, in studies of heterogeneous community samples, reporting data for the full sample precludes the investigation of the potential moderating roles of socio-economic status, ethnicity, gender and other risk factors. Razza et al. (2010) are a good example of one way in which a more detailed representation can be achieved; their sample (N=1046) was divided into two groups of differing socioeconomic status, categorised as 'poor' and 'near poor,' with data reported separately for these groups. Similarly, Rhoades et al (2011), reported separate data for families of Caucasian origin (N=531), and those of African-American origin (N=359). In these cases, providing informative data for the two separate groups was likely facilitated by the large sample sizes and the aims of the study, investigations of low-income families. Only one study, van Aken et al. (2007) reported data separately for boys, and this occurred solely because no girls were included in the study.

In summary, future investigations of the role of demographic variables, clear and consistent reporting of these variables and separate analyses for different minority ethnic groups and 'high-risk' groups and across gender and socioeconomic status would certainly contribute to our understanding of how these factors moderate the magnitude of the relationship between parenting and the development of effortful control.

Study Design

In terms of study design, there were no differences between point estimates of effect sizes ($Q=2.14$, $p=.144$) for longitudinal ($r=.19$, $p<.001$) and concurrent ($r=.13$, $p<.001$) studies. Meta-regression analyses did not demonstrate any significant regression weight for the time between assessments of parenting and the

assessment of effortful control (slope=.002, $p=.116$ including concurrent studies). These results do not reach significance, but may suggest a trend towards higher effect sizes for longitudinal rather than concurrent studies. This would lend weight to the notion of a causal role for parenting in the long term development of effortful control, since the stronger effects are seen when measurement of parenting precedes that of effortful control, and the idea that concurrent studies are perhaps more susceptible to bidirectional effects; that is, parenting behaviours being elicited by individual differences in child effortful control. Indeed, regardless of the distinction between concurrent and longitudinal studies, that effect size remains significant for longitudinal studies, with measures of parenting preceding those of effortful control, supports the notion (although by no means proves) of a causal relationship.

Amongst the longitudinal studies ($k=20$), the length of the time gap between assessments was not significantly related to the magnitude of effect size (slope=.003, $p=.434$ longitudinal studies only). Neither were the age at which effortful control (slope=-.000, $p=.969$) or parenting (slope=-.002, $p=.265$) were assessed significantly related to the magnitude of the effect size estimate. This is a potentially very interesting finding since it implies that the effects of parenting persist through childhood (the largest gap in time was 7.5 years), and are apparent even when parenting is assessed at an age when effortful control abilities are likely to have emerged.

Assessment of Effortful Control

The point estimates of effect size did not differ between observational and questionnaire assessments of effortful control ($Q=.50$, $p=.478$). This is, perhaps, to be expected, given the significant convergence of these measures (Kochanska et al., 2000).

Of all of the studies which used behavioural assessments of effortful control, only Razza et al. (2010) used a task which did not require any interaction with the experimenter (Leiter International Performance Scale-Revised). There is a substantial social component to behavioural assessments of effortful control, particularly in tasks requiring delay of gratification which were used in twelve of the 29 studies included in the meta-analysis. It is therefore difficult to discern the contribution of other factors such as compliance, conformity and emotion regulation.

There was also variability in the tasks used in behavioural assessments of effortful control. Seven papers (24%) used only tasks taken from Kochanska et al.'s (1996; 2000) effortful control battery, four (14%) used only tasks of 'executive function' (included because they assessed inhibitory control) and three (10.3%) used a combination of the two. There remains a distinction in the literature between effortful control and executive function, despite some authors arguing that effortful control and the executive function 'inhibitory control' reflect the same underlying construct (e.g. Zhou et al., 2012) and substantial crossover between assessments of the two constructs (e.g. Wiebe, Sheffield, Nelson, Clark, Chevalier & Espy, 2011). Within the studies included in the meta-analysis, several tasks were included both in papers investigating effortful control and those investigating executive function. These included Stroop-like, Go No-Go and delay of gratification tasks. Given the lack of clarity of the distinction between the two constructs, and the tasks used in assessment, it was not possible to further subdivide behavioural assessments of effortful control and executive function, which is a limitation of this moderation analysis.

In terms of method of behavioural assessment, all of the tasks used to assess behavioural control were rated or scored by researchers observing child behaviour and responses. Hence with the exception of Belsky et al. (2007), which reported data from the NICHD Study of Early Childcare (and was not selected for inclusion here due to a lack of comparability with other studies), it appears that no

studies have investigated the relationship between parenting and performance on objective measures of effortful control such as computerised tasks. Nevertheless, many such tasks exist: spatial conflict tasks (Rothbart et al., 2003), Go No-Go tasks (e.g. Simpson & Riggs, 2006; Wiebe, Sheffield & Espy, 2012) and 'executive' component of the 'Attention Network Task' (Fan et al., 2002). An understanding of the extent to which parenting is related to these more objective measures of effortful control, which are not confounded by social and emotional task demands, represents a significant gap in the research literature.

Assessment of parenting

There were no significant differences found between estimates of effect size in studies which assessed parenting using observer rating versus event coding methods ($Q=0.01$, $p=.914$) or structured versus unstructured tasks ($Q=1.44$, $p=.231$). Method of assessment of either parenting or effortful control did not, therefore, affect the magnitude of the relationship found between them. However, effect sizes did differ significantly ($Q=12.8$, $p=.002$) between studies which conducted the assessment of parenting in the laboratory ($k=13$), at home ($k=14$), or both ($k=4$). The highest combined effect size was found for studies conducting assessments of parenting in both locations ($r=.29$, $p<.001$), followed by the laboratory ($r=.19$, $p<.001$) with the lowest combined effect for studies conducting assessments of parenting at home ($r=.11$, $p<.001$).

One explanation for these findings may be that assessments conducted in the laboratory were more able to elicit and hence assess the specific parenting behaviours of interest resulting in a greater estimate of effect size. The controlled environment may also have allowed for more accurate comparison between families. This is supported by the lack of significant heterogeneity amongst studies where parenting was assessed in the laboratory. However, in contrast, there is less support from the finding that the degree of structure of the task was not a significant

moderator of the magnitude of effect size. It may also be argued that parenting assessments conducted at home are more ecologically valid and thus the combined effect size for those studies provides a more externally valid estimate.

In summary, the mechanism accounting for the moderating effect of assessment location appears unclear from the information available. This implies that the finding may be a consequence of an unknown third factor which may warrant further investigation.

Study quality

The meta-analysis was conducted using a relatively large number of independent data sets ($k=31$) reporting data on nearly eight thousand children. The overall estimate of effect size is unlikely to have been affected by publication bias. This is therefore likely to be a robust finding representing a genuine effect.

The selection criteria for inclusion in the meta-analysis were designed to ensure only studies of appropriate quality were included; studies have been subject to peer review. In addition, only studies which used observed measures of parenting, rather than self-report were included, to ensure reliable and valid measurement of parenting. There remained, however, some variation in the quality of parenting assessment, in terms of reliability, validity and blinding of coders.

In terms of measurement reliability, all but two studies reported that inter-rater reliability or agreement had been calculated. The proportion of observations rated by more than one coder ranged from 10-100% (Mean=32%, SD=25.3). Seven studies used Cohen's (1960) kappa as the measure of inter-rater reliability; all reported levels of reliability which could be considered 'substantial' to 'almost-perfect' (Landis & Koch, 1977). Sixteen studies reported correlations (Pearson's r or Intra-Class Correlation) between observers, all values were greater than 0.7, and of these, 65% reported $r>.8$ indicating a good level of agreement.

Over half the studies ($k=15$, 52%) used a published coding system for assessing parenting such as Crittenden's (2001) Care Index, the Erikson scales (Egeland et al., 1990) or Home Observation for Measurement of the Environment scale (HOME; Caldwell & Bradley, 1978). Six studies (21%) used a coding system which had been used in a previous study and eight studies (28%) do not provide a reference for the coding system used, indicating the system was most likely developed for use in the study. In general, published coding systems and those which have been used in previous research are likely to provide greater assessment reliability and validity than novel assessment methods.

Three studies (10%) explicitly stated that coders of parenting observations were blind to all other family and child data, one (3%) that coders were blind to study hypotheses and one (3%) that coders were blind to both. There were also a substantial number of studies (13; 45%) where information regarding blinding was unavailable, however since these are longitudinal studies, coding of parenting preceded the assessment of effortful control and coders would hence have been unaware of child effortful control scores. This reduces potential bias in the assessment of parenting, but may have affected the assessment of effortful control where this was also rated by the same observers. There were many studies (10; 34%) which did not state whether coders were blind to other data and both assessments were completed at the same time point. The issue with blinding in the case of these constructs assessed in this study also raises a more intrinsic problem of potential bias: both child effortful control and maternal parenting may well, at least to some extent, be apparent to observers rating either construct, even if that is not the focus of their coding. The blinding of researchers to study hypotheses would likely reduce any bias in rating and coding, however, in practise this is likely to be very difficult to implement. That there was no difference in estimates of effect size in studies which used rating scales, compared to those which used event coding, which is arguably less susceptible to bias, or in concurrent versus longitudinal

studies, would seem to that coder bias was not a significant factor in the reported associations.

In terms of the method of assessment used to determine levels of effortful control, all studies using questionnaires used variations of the highly validated 'Child Behaviour Questionnaire' assessment of temperament (Rothbart et al., 2001) thus ensuring high quality parent-report and comparability of results between studies. Studies using behavioural assessment of effortful control tended to implement well-established behavioural task batteries (e.g. Kochanska et al., 1996; 2000). As discussed above, however, only one study included in the analysis used an objective measure of effortful control.

In summary, whilst numerous steps were taken in study selection and inclusion, there remained some variability in study quality. Nevertheless, since most points of the funnel plot (see Figure 2), were within the expected range of variability/standard error, it is unlikely that this variability in quality resulted in substantial variability in estimates of effect size, beyond that which would otherwise be expected. This notion is further supported by the results of the 'trim-and-fill' analysis.

Generalisability

With regard to the generalisability of this effect in terms of the populations studied, it is of note that the study set comprised predominantly white (74%; k=24), socioeconomically non-disadvantaged (59%) families with two parents living in the household (66%; k=20). Most (79%) studies were conducted in the United States of America, and all but one (Feldman et al., 1999) within North America or Western Europe. The moderation analyses indicated that the significant association persisted, albeit reduced in magnitude, across these demographic factors, and, whilst not the majority, there remained a substantial number of families from less well represented groups (minority ethnic, low SES, single parent households).

There were also no differences ($Q=0.02$, $p=.880$) between effect sizes for studies conducted in the US ($r=.16$, $p<.001$) and elsewhere ($r=.17$, $p<.001$). It is therefore highly likely that the findings are not unique to white middle class American households and do indeed generalise to wider, typically developing populations, at least in the West.

By design, the included studies were limited to typically developing children, and the results cannot therefore be generalised to families of children at neurodevelopmental risk such as children with ADHD (e.g. Martel & Nigg, 2006) or those born at very low birth weight (Poehlmann, Schwichtenberg, Shah, Schlafer, Hahn & Maleck, 2010).

In terms of research design, the effect also persisted across different parent observation methods and coding schedules, across both parent-report and behavioural observations of child effortful control and across both concurrent and longitudinal studies. Given the significant difference in effect sizes between observations of emotional, versus limit-setting, aspects of parenting, it is possible that the effects are specific to particular parenting behaviours.

General Limitations

Meta-analysis provides a systematic, rigorous and replicable means of evaluating the outcomes of multiple studies to establish an estimate of the overall relationship between two variables. Nevertheless, there remain methodological limitations which should be considered in the interpretation of overall findings.

Primarily, as discussed above, the identification of a significant association between parenting and effortful control provides little elucidating information regarding the causal nature of the relationship. Bidirectional, transaction, reciprocal and interactive effects are important considerations in interpreting the identified association between parenting and effortful control. Karreman et al. (2006) argue that, particularly in community samples, parents may well demonstrate 'good-

enough' levels of parenting which could reduce the magnitude of the effect sizes found, and that these associations may be more likely a consequence of parenting effects elicited by individual difference in child effortful control. Whilst this is perhaps more relevant to their study, which included only concurrent investigations, Kiff, Lengua and Zalewski (2011) concur that *'the relations between parenting and temperament ... are complex.'* There is good evidence to suggest that there may well be other, important, variables not considered here such as genetics (Goldsmith, Buss and Lemery, 1997; Yamagata, Takahashi, Kijima, Maekawa, Ono & Ando, 2005), home environment (Lemery-Chalfont, Kao, Swann, Goldsmith, 2013; Valiente et al., 2007), maternal psychopathology (Gartstein & Fagot, 2003) and maternal effortful control (Bridgett, Gartstein, Putnam, Oddi Lance, Iddins, Waits et al., 2011).

Secondly, the meta-analysis was limited by the literature under review, and constrained to the information available within the set of included studies and by the quality of the studies. Thus, the moderation analyses were limited by the lack of separate reporting of data for different socioeconomic, ethnicity and gender groups, and the lack of clarity and consistency in how these are assessed. Similarly, moderators were frequently coded as one of only two categories, reducing precision, due to the lack of clarity regarding, for example, the parenting constructs, effortful control tasks, socioeconomic status. In these cases, the moderation analysis was constrained to investigation of only two distinct, but likely heterogeneous, groups of studies.

Finally, the rigorous process of selecting a single study where there have been multiple reports of the same dataset, effect size extraction and moderator coding introduces a further limitation. The application of somewhat arbitrary rules, designed to ensure consistency and the ability of other researchers to replicate the findings, resulted in the loss of data across studies where, for example, parenting and effortful control were assessed at numerous time points.

Guidelines for future research

There is substantial evidence for the role of effortful control for later adjustment and functioning, and the current meta-analytic findings implicate role of parenting in the development of effortful control. Further understanding of the role of parenting would thus be of clinical utility in supporting and promoting the development of this important temperament trait. Accordingly, six suggestions for the direction of future research, informed by the findings of the current study are described below:

1. Dissociating the role of different parenting factors

The results of the moderator analysis indicate that emotional aspects of parenting such as warmth and sensitivity are more strongly associated with levels of child effortful control than aspects of parenting relating to limit-setting, structure and scaffolding. However, there were insufficient studies included in the study set to enable more detailed investigation of the separate effects of the different parenting constructs which fall into these categories. A focus on the assessment of clearly and consistently defined, specific parenting constructs and their association with child effortful control is therefore recommended in order to dissociate the most significant aspects of parenting.

2. Elucidating causality and mechanisms of association

Investigation of the direction or mechanism of the association between quality of care and effortful control abilities is beyond the scope of this study. Since it is now clear that a significant association exists, one key next step would be for the focus of studies to shift from investigating the presence of an association, to investigating the nature of the association, the direction of causality and further exploring the role of mediating factors such as maternal personality and effortful control and possible gene x environment interactions.

3. Assessing the role of demographic factors

Demographic factors such as socioeconomic status and ethnicity appear to moderate the association between maternal caregiving, and data regarding children of different genders was largely unavailable for this analysis. Accordingly, further investigation into the role of these factors in the association between parenting and effortful control would be a helpful focus in developing our understanding.

4. Assessing the role of fathers

This study focused on maternal caregiving, however, despite its potential importance, it was apparent from the papers identified during the literature review process that the role of the father-child relationship has not received the same level of attention from researchers. Given the significant association with maternal parenting behaviours here, it would be important to also investigate the association with paternal parenting behaviours.

5. Investigating clinical and high risk populations

There is some evidence to suggest that the association between parenting and child effortful control can be generalised to children at developmental risk, for example those born at very low birth weight (Poehlmann et al., 2010). Further investigation into this association for this group of children, and others such as those with ADHD would serve to further develop the evidence base regarding the development of effortful control, and may potentially be of substantial clinical utility.

6. Investigating objective measures of effortful control

Finally, as noted, there has been a focus in the current literature on the assessment of effortful control through the use of questionnaire and behavioural task batteries. Whilst these are well-established assessments of demonstrated

reliability, a degree of subjectivity remains in their reliance on parent-report and tasks with a substantial social element. Replication of the findings of these studies using objective measures of effortful control, free from rater bias such as computerised Go No-Go or Flanker tasks would thus be an important contribution to the literature.

Conclusions

This meta-analysis provides robust evidence, from a large sample set, for the significant association between maternal parenting behaviour and child effortful control. The effect is greater for emotional aspects of parenting but consistent across questionnaire and behavioural measures of effortful control, unaffected by the age at which these are assessed or whether data is collected concurrently or longitudinally. Demographic variables such as socioeconomic status, ethnicity and the proportion of household where parents are cohabiting appear to moderate the magnitude of the association. It is recommended that research focus should now shift to an investigation of the causal mechanisms of the relationship, and further understanding of moderating and mediating factors.

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Part 2: Empirical Paper

Parenting and Effortful Control:

An EEG Study

Abstract

Aims: This study aimed to examine the neural correlates of performance on the executive attention component of the Attention Network Task (Fan, McCandliss, Sommer, Raz and Posner, 2002) using electroencephalography (EEG). Further, it aimed to investigate the relationships between these neural correlates, parent-reported effortful control and early quality of care.

Methods: Mother-infant dyads originally participated when the infants were ten months old. Observations of maternal behaviour and dyadic interaction were conducted and coded using the Coding Interactive Behaviour scales (CIB; Feldman, 1998). Forty six children aged 69 to 81 months participated in the follow up study. Children completed the executive attention component of the Attention Network Task, and EEG was recorded using a 128 channel geodesic sensor net. The LPC and N2 event-related potentials were investigated. Parents completed parent-report measures of child effortful control.

Results: There was a significant effect of trial type on LPC mean amplitude at the right lateral location, and no significant midline effects of trial type for the N2 ERP component. There were significant correlations between parent-report measures but these did not relate to behavioural task performance or LPC or N2 mean amplitudes. The correlation between parent-reported effortful control and maternal behaviour was on the threshold of significance. There were no other relations between parent-report, behavioural scores or neural indices of task performance and early quality of care.

Conclusions: There appear to be effects of congruency on LPC mean amplitude at lateral frontal sites in children at age six, however effects on N2 are likely to emerge later. Further research using a larger sample size is required to investigate the relations between performance on the Attention Network Task and early quality of care. The exploratory ERP findings may represent a novel contribution to our understanding of the neural correlates of task performance, but replication is required.

Introduction

Effortful Control

Effortful control is defined as *'the ability to inhibit a dominant response to perform a subdominant response, to detect errors, and to engage in planning'* (Rothbart and Rueda, 2005). Conceptualised as a temperamental trait, individual differences in effortful control are thought to arise through a combination of genetic heritage and environmental influence (Rothbart and Rueda, 2005).

Effortful control abilities emerge in the first year of life, consolidate after the second year of life (Posner & Rothbart, 2000) and continue to develop throughout the pre-school years (see Rothbart, Posner and Kieras, 2008 for a review). There is substantial evidence for the importance of effortful control in later behavioural, academic, social and emotional adjustment and functioning (Blair & Razza, 2007; Carlson & Wang, 2007; Dennis, Brotman, Huang & Gouley, 2007; Eisenberg, Spinrad, Fabes, Reiser, Cumberland, Shepard et al, 2004; Kieras, Tobin, Graziano & Rothbart, 2005; Kochanska & Knaack, 2003; Liew, Chen & Hughes, 2010; Liew, McTigue, Barrois & Hughes, 2008; Olson, Sameroff, Kerr, Lopez, Nestor & Wellman, 2005; Spinrad, Eisenberg, Gaertner, Popp, Smith, Kupfer et al., 2007; Valiente, Lemery-Chalfont & Reiser, 2007).

Assessment

Classically, parent-reported effortful control is assessed using the Child Behaviour Questionnaire (CBQ; Rothbart, Ahadi, Hershey, & Fisher, 2001). This is a 195-item measure, designed for children aged three to seven years. Statements about the child are rated according to a seven-point Likert scale, across fifteen dimensions of temperament. The effortful control factor is comprised of the 'Attentional Focusing,' 'Inhibitory Control,' 'Low Intensity Pleasure' and 'Perceptual Sensitivity' subscales. Various versions have been developed for use across childhood (Infant Behaviour Questionnaire, Rothbart, 1981; Gartstein & Rothbart,

2003; Early Childhood Behaviour Questionnaire, Putnam, Gartstein & Rothbart, 2006, Temperament in Middle Childhood Questionnaire, Simonds & Rothbart, 2004; Early Adolescent Temperament Questionnaire, Ellis & Rothbart, 2001).

Behavioural assessment batteries of effortful control have also been developed. These include tasks designed to assess the key effortful control abilities: to inhibit a dominant response, focus attention, resolve conflict and delay gratification (Rueda, 2012; p148). Most frequently used is the Effortful Control Battery, developed by Kochanska and colleagues (Kochanska, Murray & Harlan, 2000; Murray and Kochanska, 2002). This battery, used with children aged from two years, comprises a total of eleven tasks assessing the ability to delay gratification, to slow down motor activity, to suppress and initiate activity according to a signal, to utilise effortful attention in Stroop-like tasks, and to lower one's voice. Performance on these tasks is scored or coded by an observer.

Finally, computerised tasks are also used in effortful control research. These are drawn from cognitive psychology and cognitive neuroscience, and comprise an element of conflict between stimuli and/or responses (Rueda, 2012, p149). The tasks assess executive attention and response inhibition, thought to be the underlying mechanism of effortful control (Rothbart, Derryberry, & Posner, 1994; Rothbart, Sheese & Posner, 2007). Examples include the flanker (Eriksen and Eriksen, 1974) component of the 'Attention Network Task' (Fan, McCandliss, Sommer, Raz and Posner, 2002), spatial conflict tasks (e.g. Rothbart, Ellis, Rueda and Posner, 2003) and Go No-Go tasks (e.g. Simpson and Riggs, 2006; Wiebe, Sheffield & Espy, 2012). Typically, reaction times and accuracy are recorded, providing an objective measure of ability. Performance on these tasks is significantly associated with parent-reported effortful control (Chang & Burns, 2005; Gerardi-Caulton, 2000; Simonds, Kieras, Rueda & Rothbart, 2007). In addition to providing an objective measure of ability, computerised tasks also facilitate the

investigation of the neurological systems underlying effortful control abilities (Rueda, 2012, p151).

Rothbart et al. (2007) propose the underlying mechanism of effortful control lies in the executive (or 'anterior') attention network (e.g. Rothbart, Derryberry & Posner, 1994). Rothbart and colleagues (Rothbart, Sheese & Posner, 2007; Rueda, Posner & Rothbart, 2005) have thus proposed that the executive attention, flanker task component (Eriksen and Eriksen, 1974) of the Attention Network Task (Fan et al., 2002) is a particularly useful assessment tool in the investigation of the development of effortful control. This computer-based task requires participants to respond to a central stimulus which is flanked on either side by either congruent (the same) or incongruent (different) stimuli. This is considered to be a conflict task, where participants must select a sub-dominant response in the presence of a competing response (Rueda, Posner, Rothbart and Davis-Stober, 2004), consistent with the definition of effortful control. Indeed, interference between congruent and incongruent trials has been found to be significantly associated with parent-reported effortful control (Checa, Rodríguez-Bailón & Rueda, 2008; Simonds et al., 2007).

Electroencephalography

Electroencephalography (EEG) records electrical activity across the scalp, reflecting underlying cortical brain activity. The Event Related Potential (ERP) technique enables examination of the neural activity evoked in response to discrete stimuli or events (Nelson and McCleery, 2008). EEG studies offer the opportunity to assess underlying brain mechanisms of task performance with high temporal resolution.

The EEG methodology has frequently been employed to assess neural activity in children and young people during completion of computerised tasks associated with effortful control such as the Attention Network Task (e.g. Rueda, Rothbart, McCandliss, Saccomanno & Posner, 2005), Go No-Go tasks (Ciesielski,

Harris & Cofer, 2004; Johnstone, Pleffer, Barry, Clarke & Smith, 2005; Wiersema & Roeyers, 2009), spatial-conflict tasks (Rubia, Halari, Smith, Mohammad, Scott & Brammer, 2009) and Stroop tasks (Larson, Clawson, Clayson & South, 2012).

A child-friendly version of the Attention Network Task has been developed (Rueda, Fan, McCandliss, Halparin, Gruber, Lercari et al., 2004). Behavioural performance in this task has been investigated thoroughly, and much is known about the task's behavioural properties. Only recently, however, have researchers begun to investigate the underlying neurophysical correlates of task performance. A search of the literature revealed only three studies that have investigated the neural correlates of performance on the Attention Network Task in children: Buss, Dennis, Brooker and Sippel (2011) investigated children aged four to eight years, Rueda, Checa & Cómbita (2012) investigated children aged five and Rueda, Posner et al. (2004) investigated children aged four. Broadly speaking, these papers indicate that conflict performance in the attention network task may be associated with two ERPs: the Late Positive Component (LPC) and the N2.

Late Positive Component

Rueda, Posner et al. (2004) found effects of congruency (that is, a difference between congruent and incongruent trials), from 550ms across frontal electrodes located in left (F3), right (F4) and central scalp locations (Fz; for a map of electrodes see Appendix 2). At these electrode sites, peak amplitudes were more negative for incongruent trials. The paper reports two follow-up analyses which also support the presence of a congruency effect at frontal scalp locations. Firstly, in the 600-1000ms time window, amplitudes were significantly more negative in the incongruent condition across ten frontal electrodes. Secondly, mean amplitudes at Fz showed significant differences between the incongruent and congruent condition between 600 and 1000ms, and at the midline parietal site (Pz) between 800 and 1100ms. The authors identify this effect as the LPC.

Rueda et al (2012) also report significantly more negative amplitudes in the incongruent condition between 485 and 550ms at anterior frontal sites (AF). The effect at this location was shown again, between 580 and 715ms upon the second administration of the task, six weeks later. This effect is relatively consistent with Rueda, Posner et al. (2004); occurring in a similar location, and although the timing is somewhat earlier, this may be a consequence of faster overall reaction times in the slightly older group participating in the Rueda et al. (2012) study.

Similar ERP findings have been demonstrated in a Go No-Go task with children aged six (Davis, Bruce, Snyder & Nelson, 2003), with effects of trial type for the LPC at central, left and right frontal electrode locations (Fz, F3, F4). Davis et al. (2003) suggest that the LPC reflects the withholding of a response, or conflict monitoring. Rueda, Posner et al. (2004) similarly argue that the LPC congruency effect is likely to reflect conflict monitoring.

N2 Component

The N2 is a negative going waveform which appears around 200-400ms after stimulus onset and is maximal at frontocentral electrodes (for a map of electrodes in a 128 channel net see Appendix 2). It emerges as a negative deflection that is larger (more negative) for incongruent trials (Rueda, Posner and Rothbart, 2005). It is thought to be an index of cognitive control (Folstein & Van Petten, 2008) or response inhibition (Kopp, Rist & Mattler, 1996).

Using the Attention Network Task, Buss et al., (2011) found a significant effect of flanker type in the N2 at the centrally located Cz electrode in the older half of their sample; 12 children aged six to eight years. Amongst the whole sample, the authors found that N2 amplitude for incongruent trials, and the difference between N2 amplitude for incongruent and congruent trials, positively correlated significantly with parent-reported levels of effortful control.

In their study of 22 younger children (aged 4 years), Rueda, Posner et al. (2004) did not identify any significant effect of congruence on N2 peak amplitude in frontal leads (Fz, Fc3, Fc4; Cz was not investigated in the study) using the same task. Rueda et al. (2012) also found no effect on congruence on N2 amplitude during the Attention Network Task in a group of 37 five year old children (Rueda et al., 2012) across anterior frontal (AF/Fz) and fronto-posterior leads (Fcz, Cz). It appears, therefore, that the effect of congruency at N2 has been observed only in older children, after approximately the age of six years.

In summary, the available evidence implicates two key ERP components in the performance of a flanker task. In particular, there appears to be consistent evidence for an effect of congruency on the LPC in younger children (Rueda, Posner et al., 2004; Rueda, et al. 2012). Accordingly, this study will investigate the LPC as the key component of interest for assessing effortful control in children of this age. Evidence regarding the N2 in children is less consistent, although generally shows no effect of congruency in younger children, with these effects emerging after age six. No studies have thus far investigated effects of congruency in children at the age of the current sample (six years). This study will also therefore explore whether there is an effect of congruency on N2 amplitude in children age six and the relations between the N2 and effortful control.

Quality of Care and the Development of Effortful Control

Given the substantial evidence for the importance of effortful control for later adjustment, it is not surprising that significant efforts have been made to elucidate the genetic and environmental factors promoting its development. A key area of research attention has been the quality of care received and the relationships with caregivers in the first years of life.

The vital role played by early experiences with caregivers is evidenced through work with children exposed to extreme deprivation early in life and thus

deprived of these relationships (Rutter, Kreppner and O'Connor, 2001; Stevens, Sonuga-Barke, Kreppner, Beckett, Castle, Colvert et al, 2008; Webster, Hackett, Kisst and Joubert, 2009). Studies in more normative samples, described below, investigating the quality of maternal caregiving also indicate the association between early quality of care and later individual differences in effortful control.

Parenting and Effortful Control

The first part of this thesis reviewed the literature regarding the association between parenting behaviours and the development of effortful control. The meta-analysis revealed a significant association between parenting and child effortful control (Carman, 2013). This association appears to be larger for emotional aspects of parenting rather than those relating to limit-setting, structure and boundaries.

The review of the literature identified a number of studies evidencing a significant association between parent-reported levels of effortful control and emotional aspects of parenting such as warmth, sensitivity and expressivity (Eisenberg, Gershoff, Fabes, Shepard, Cumberland, Losoya et al., 2001; Eisenberg, Zhou, Losoya, Shepard, Murphy, Reiser et al., 2003; Mintz, Hamre & Hatfield, 2011). A number of papers also identified a significant association between these emotional aspects of parenting and performance on behavioural task batteries (Eiden, Edwards & Leonard, 2007; 2009; Graziano, Keane & Calkins, 2010; Jennings, Sandberg, Kelley, Valdes, Yaggi, Abrew et al., 2008; Kochanska et al., 2000). Thirdly, the review identified a number of papers identifying a significant association between child levels of effortful control and the quality of the parent-infant relationship (Feldman, Greenbaum and Yirmiya, 1999; Kochanska, Aksan, Prisco & Adams, 2008; Li-Grining, 2007).

Despite the attention devoted to investigating the importance of early quality of care and the quality of the mother-infant relationship in the development of effortful control, the review concluded that these studies have almost solely relied on

parent-report measures or behavioural task batteries (Carman, 2013). The one exception, Belsky, Fearon & Bell (2007), reporting data from the NICHD Study of Early Child Care (1993), found that performance on the Continuous Performance Test of attention regulation at age six and age nine years was predicted by greater maternal sensitivity at age 54 months and six years. However, although a test of attention, the CPT does not specifically assess 'executive attention,' and higher scores have been argued to reflect sustained attention and lack of impulsivity (Halperin, Sharma, Greenblatt & Schwartz, 1991) rather than inhibitory or effortful control.

Thus, whilst there is good evidence to suggest a significant association between early quality of parenting and the development of effortful control, research utilising objective assessment methods of effortful control is sparse. In addition, the review did not identify any papers investigating associations between parenting and underlying neural correlates or indices of effortful control, which represents an important gap in the literature for understanding the extent, direction and mechanisms of the association.

The Present Study

The present study is the first of its kind to assess the relationship between parenting and later effortful control abilities using the executive attention component of the computerised Attention Network Task. The study also aims to investigate the neural indices of task performance in children, adding to the currently limited body of literature, and explore the relationship between measures of parenting and these indices. The key primary index of conflict/inhibition will be the LPC, given the reasonably consistent evidence suggesting that this component is related to congruency in younger children. The N2 will also be investigated, given the significant effects identified in older children, and the small number of studies that have recruited young children as participants.

This study hypothesised that:

1. There would be a significant effect of congruency on mean amplitude on the LPC EEG index of conflict/inhibition. In addition, in light of the role of the N2 in congruency in older children, and the small number of studies of younger children, the N2 will also be examined.

2. EEG neural indices of conflict/inhibition during the executive attention component of the Attention Network Task would be associated with individual differences in behavioural task performance: reaction time and accuracy conflict effect.

3. A reduced 'conflict' effect on behavioural measures would be associated with higher levels of parent-reported effortful control.

4. Neural indices of conflict/inhibition would be associated with individual differences in parent-reported effortful control.

5. Higher quality of parent-infant interaction (observed maternal parenting) would be associated with parent reports of higher effortful control.

6. Higher quality of parent-infant interaction would be associated with better performance on the executive attention component of the Attention Network Task, defined as a reduced 'conflict' effect.

7. The quality of early parent-infant interaction would be associated with EEG indices of conflict/inhibition.

Method

Design

This is a two-wave longitudinal study. Mother-infant dyads initially attended the lab twice when the infant was aged ten and twelve months to participate in a parenting and attachment study. Families were then contacted when the children were approaching their sixth birthday and invited to participate in a follow-up study. This study involved a one-off visit to the laboratory where behavioural, EEG and parent-report measures of effortful control were gathered.

Participants

Recruitment

The original sample comprised 124 mother-infant dyads (46.8% male). Dyads were recruited from the local area using flyers and posters. For the age six years follow-up study, families were initially contacted by letter (see Appendix 3), and follow-up phone calls were subsequently made to book attendance. Emails were sent if no address or telephone numbers were available.

Participant flow is summarised in Figure 1. Of the 124 families who participated originally, 96 children were within the age criteria of the study (being older than five years nine months at the time of testing). Of these 96 eligible children, a total of 47 (49%) returned to participate and attended all or part of the testing session. EEG data were not collected for two participants, and a further seven were excluded from EEG analysis due to poor data quality (see below).

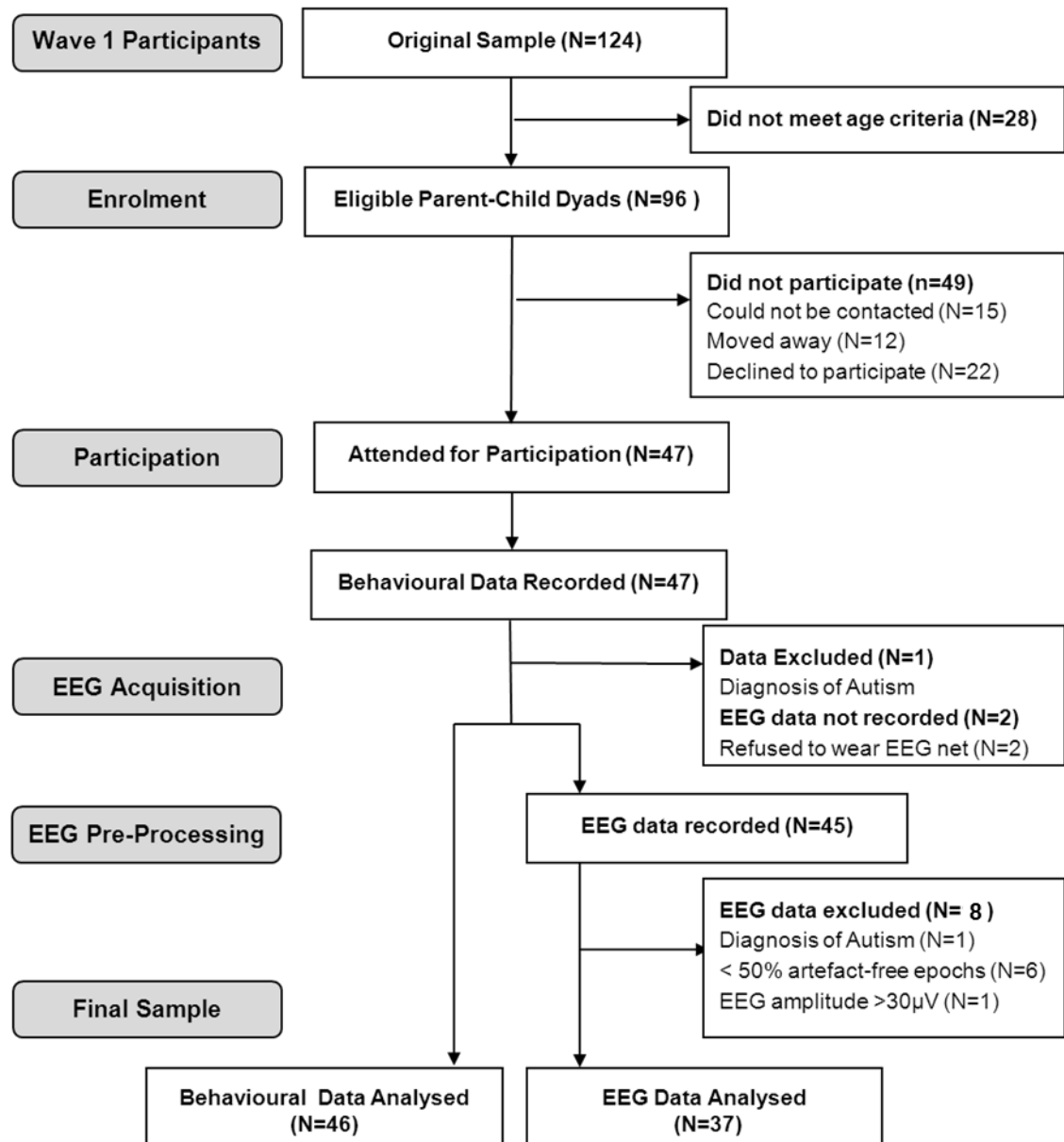


Figure 1: Participant flow through recruitment to final analysis.

Current Sample

The final sample reported for this study comprises 46 children (24 boys, 52%). The children were aged six years (mean=73.1 months, SD=2.65) when they attended the centre for assessment of effortful control. Assessments of parenting were conducted when the children were an average of 321 days old (SD=12.8 days). Most (64%) were firstborn children (N=39).

The children generally came from middle class families. The majority of families in the sample (76%) reported household incomes of greater than £40,000 (in 2007, N=41). Most fathers (71%; N=42) and mothers (85%; N=46) were educated to at least degree level.

The ethnicity of most children was Caucasian: White British (46%), White European (20%) or White Other (Australian; 7%). Nearly a quarter (24%) were of mixed heritage: White British/European and African-Caribbean (9%), White British/European and Asian (11%), Asian and Black African-Caribbean (2%). One child (2%) was of Asian origin.

Power Analysis

In preparing the research proposal, a statistical power analysis was conducted. Using an effect size of $r=0.37$ for the relationship between parental sensitivity and effortful control, (Mintz et al., 2001), power set at 80% and $\alpha=0.05$, the analysis indicated that a total sample size of 65 participants was required. The power analysis is considered further in the Discussion section, in light of the outcome of Volume 1 of this thesis.

Procedures

Wave 1: Parenting (age ten months)

Mother-infant dyads attended the laboratory on two occasions, eight weeks apart. During the initial visit, the mother and infant participated in a semi-structured observation session of approximately six minutes duration, in order to assess mother-infant interaction quality. Data collected from this wave of the study were not collected as part of the thesis research but were shared for use in data analysis.

Wave 2: Effortful Control (age six years)

Participating children attended a single laboratory-based testing session accompanied by a parent. The session lasted for approximately two hours. At the beginning of the session, study procedures were explained to both the child and parent, and informed consent obtained from the parent (see Appendices 4 and 5 for information sheet and consent form). Following this, the EEG net was applied, and the children completed two computer-based tasks. One of these tasks was developed for the thesis of Sophie Bennett, with whom this thesis was jointly conducted; data from this task are not reported here (see Appendix 6). The order of the tasks was counterbalanced such that the task reported here was conducted as the first task half the time. The EEG net was then removed and, after a short break, children completed the Story Stem Assessment Protocol (SSAP; Hodges, Steele, Hillman, Henderson & Kaniuk, 2003). Data from this task do not form part of this report.

Parents were invited to watch the EEG net application but waited outside whilst the computer tasks and SSAP were completed. Parents were asked to complete the questionnaire forms during this time. Maternal report data was gathered by post if children were brought to the laboratory by fathers. At the end of the testing session parents were debriefed and children were rewarded with a £5 book token.

Ethics

Ethical approval was received from the UCL research ethics committee (see Appendices 7a and 7b). Since the research involved young children, informed consent was sought from parents (see Appendices 4 and 5). The wellbeing of the participating children was paramount at all times. Child assent was always sought, and children were told that they could stop at any time by telling the researchers or their parents, emphasising that they would not be in trouble if they did so. Time was

always taken to describe and explain the process of the assessment and answer any questions from both parents and children.

Children were encouraged to sit very still and concentrate during the behavioural tasks and EEG data acquisition, and praised for doing so. Specific feedback on task performance was provided only at the end of the behavioural tasks, in order to prevent any impact on performance. Opportunities for breaks, drinks and snacks were provided regularly and frequently.

Wave 1 Measures

Quality of Mother-Infant Interaction

The quality of mother-infant interaction was assessed using the Coding Interactive Behaviour scales (CIB; Feldman, 1998). This a global coding system comprised of 42 codes (21 parent, 16 child and 5 dyadic) each rated on a Likert Scale from one (low) to five (high). The CIB scales have been used and validated in several previous studies, shown sensitivity in variation related to child age, biological and socio-emotional risk and cultural background and acceptable to high levels of internal consistency (Feldman, 2000; Feldman, Eidelman, Sirota, & Weller, 2002; Feldman, Greenbaum, Mayes, & Erlich, 1997; Feldman, Masalha, & Nadam, 2001; Keren, Feldman, & Tyano, 2001, Mayes, Feldman, Granger, Haynes, Bornstein & Schottenfeld, 1997).

The CIB scales include 21 parent behaviour codes. These represented three subscales: Maternal Sensitivity, Maternal Intrusiveness and Maternal Limit Setting. Maternal Sensitivity included the following codes: Acknowledging, Imitating, Elaborating, Parent Gaze/Joint Attention, Positive Affect, Vocal Appropriateness, Appropriate Range of Affect, Resourcefulness, Praising, Affectionate Touch and Parent Supportive Presence. The second code, Maternal Intrusiveness included: Forcing, Overriding, Parent Negative Affect/Anger, Hostility, Parent Anxiety and Criticizing. Finally, the Limit-setting codes were: Consistency of Style, On Task

Persistence, Appropriate Structure and Appropriate Limit-Setting. All observations were coded by two trained raters, blind to the longitudinal study hypotheses.

The CIB also yields five dyadic codes representing two subscales. The Reciprocity subscale was comprised of Dyadic Reciprocity, Adaptation-Regulation and Fluency, and the Negative subscale of Constriction and Tension.

Observation was conducted in the laboratory, in two naturalistic situations. The observation session comprised two three-minute segments of parent-infant interaction and recorded using a digital video camera. Parents were instructed to interact with their infant as they normally would. In the first three-minute segment, mothers were asked to play with their infant with toys provided. In the second, mothers were asked to play with their infant without any toys.

Wave 2 Measures

Behavioural Assessment of Effortful Control

Participants completed the executive attention component of the Attention Network Test, which consists of a flanker task (Eriksen and Eriksen, 1974). Flanker tasks typically involve presentation of a target (for example < or >) flanked by congruent or incongruent distractors, resulting in two congruency conditions. The Attention Network Task (Fan et al., 2002) has been designed to be suitable for children (Rueda, Fan, et al., 2004). The procedure was based on the paradigm described in Rueda, Posner et al. (2004). The task was kindly supplied by the authors and was run using E-Prime (Psychological Software Tools, Pittsburgh, PA) on a Dell desktop computer.

The full Attention Network Task also includes 'Alerting' and 'Orienting' components, with cueing conditions, and stimuli appearing at different locations on the screen (Fan et al., 2002). In order to assess only the 'executive attention' component, all cues were removed and the stimuli were all presented in the same location in the centre of the screen.

The targets and distractors in this version of the task are drawings of fish; the central fish is the target. Five fish appear in a horizontal line in the centre of the screen and are either facing left or right. Children are told that this central fish is hungry, and they will make it happy by feeding it. To feed the fish, the children must press the mouse button (left/right) corresponding to the direction in which the fish is facing. They are instructed to ignore the other fish, and respond as quickly and accurately as possible (for the full instructions, see Appendix 8). In congruent trials, all the fish are facing in the same direction. In incongruent trials, the target fish is facing the opposite direction to the four flanker fish. There are an equal number of congruent and incongruent trials, displayed at random.

A schematic representation of the task is presented in Figure 2. A fixation cross is displayed in the centre of the screen for 800ms. The target display then appears and remains on the screen until the child responds, or for up to 5000ms. Feedback is provided, in the form of an animation lasting 1000ms. For correct responses, the animation shows the fish looking happy with bubbles coming up from its mouth, for incorrect responses the fish looks sad with bubbles coming down from its eye. A 'woohoo' sound plays for correct responses, incorrect responses elicit a buzzing sound.

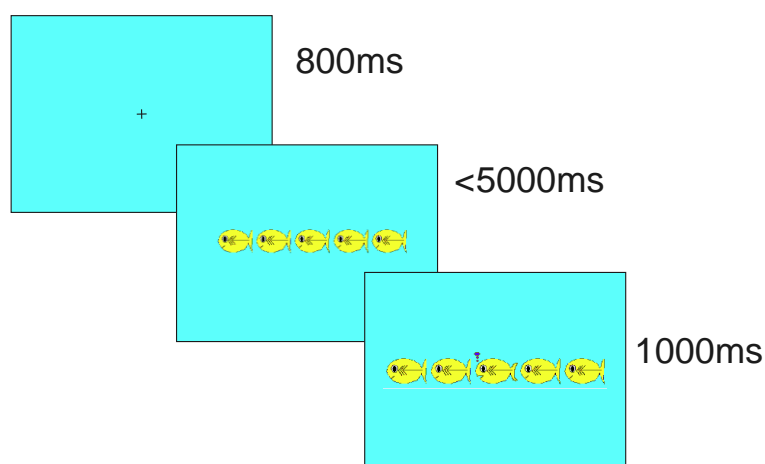


Figure 2: Schematic representation of task stimuli presentation.

The instructions were given using four example trials (one of each condition, left/right and congruent/incongruent) on the screen with unlimited time for explanation and questions. Children then completed twelve practice trials and advanced to the main assessment task once they had demonstrated an understanding of the instructions.

The main assessment task comprised of five blocks of twenty trials. The task was set to advance automatically between the trials in each individual block. The beginning of each block was initiated by the experimenter. Whilst Rueda, Posner et al. (2004) report each trial being initiated by the experimenter, piloting revealed that children were able to focus on the screen and respond appropriately during each block of trials without the need for this. Mean reaction times and accuracy scores were recorded for each trial.

Electroencephalogram Data Acquisition

EEG data were collected during the Attention Network Task using 128-channel HGSN sensor nets (Electrical Geodesics, Inc.). Data were recorded using Net Station (Electrical Geodesics, Inc.). The sampling rate was 250 Hz. During data acquisition, a low-pass filter of 70Hz was applied.

Parent-Report Measures

Child Behaviour Questionnaire

Effortful Control was assessed using the Attention Focusing, Inhibitory Control, Low Intensity Pleasure and Perceptual Sensitivity subscales of the Child Behaviour Questionnaire (Putnam and Rothbart, 2006; Rothbart, Ahadi, & Hershey, 1994; Rothbart et al., 2001). This is a 94-item parent-report questionnaire designed for children aged three to seven years. Mothers rated statements according to a Likert scale, from one ('extremely untrue') to seven ('extremely true').

The 'Attention Focusing' subscale comprises six items intended to assess the child's ability to focus and sustain their attention on a task, such as '*Is easily distracted when listening to a story.*' The 'Inhibitory Control' subscale is made up of six items, such as '*Can wait before entering into new activities if s/he is asked to,*' assessing the child's ability to suppress responses. The 'Low Intensity Pleasure' subscale assesses the child's degree of pleasure or enjoyment taken from situations where stimuli are of low intensity, rate, complexity or novelty. It comprises eight items such as '*Enjoys taking warm baths*' and '*Likes being sung to.*' Finally, the 'Perceptual Sensitivity' subscale consists of six items such as '*Seems to listen to even quiet sounds*' and '*Comments when a parent has changed his/her appearance.*' It assesses the child's ability to detect minor, low-intensity stimuli in their external environment.

Subscale scores were calculated by recoding inversely presented items and calculating the mean response for all items of the subscale. The mean of these four subscales was calculated to determine an overall score for Effortful Control. Internal consistency was very good (Cronbach's $\alpha=0.81$).

Executive Function

Executive function was also assessed using the parent-report Behaviour Rating Inventory of Executive Function (BRIEF; Gioia, Isquith, Guy and Kenworthy, 2000). This is an 86-item questionnaire, designed for children aged 5-18 years. Parents rate items according to a three point Likert Scale describing behaviour as happening 'Never' (1), 'Sometimes' (2) or 'Often' (3). The measure yields eight subscales related to the executive function domains. Consistent with the definition of effortful control, the Inhibit subscale was used for analyses. The Inhibit subscale is comprised of 10 items about the child's behaviour designed to assess their ability to resist impulses and stop behaviour if necessary such as '*blurts things out,*' and '*gets out of the seat at the wrong times.*' Internal consistency was very good

(Cronbach's $\alpha=.87$). All scores were converted to T scores using appropriate age and gender norms (Gioia et al., 2000).

Behavioural Screening

Parents completed the 25-item Strengths and Difficulties Questionnaire (Goodman, 1997). This is a short screening measure for 4-16 year olds, used to assess emotional symptoms, conduct problems, hyperactivity/inattention and peer relationship problems, as well as prosocial behaviour. Parents rate statements about their child on a three-point Likert Scale (Not True, Sometimes True, Certainly True). The questionnaire has been well validated for use in the UK and shows good reliability and validity (Goodman, 1997; Goodman & Goodman, 2011).

Included in the analysis was the hyperactivity/inattention scale. This is made up of five items such as '*easily distracted, concentration wanders*' and '*thinks things out before acting*'. Internal consistency was high (Cronbach's $\alpha=.81$). In validation studies, this scale has been demonstrated to be at least as good at detecting inattention and hyperactivity as the Rutter (Elander & Rutter, 1996) scales (Goodman, 1997) and the Achenbach (1991) Child Behaviour Checklist (Goodman & Scott, 1999).

Data Completeness

Complete Wave 1 CIB data are available for all children who participated in the study. All children who attended completed the computerised task and hence behavioural data is available for the full sample. Full questionnaire data was also provided by all parents.

Two children refused, upon attending, to wear the geodesic sensor net for EEG data acquisition, and data of sufficient quality were not available from a further seven (see below). EEG data is therefore available for 81% of the sample (N=37). There were no significant differences in questionnaire, CIB or behavioural task

performance scores between children for whom EEG data is available and those for whom it is not. The children for whom EEG data was used were significantly younger ($M=72.7m$, $SD= 2.31$) than those for whom it was not ($M=74.9m$, $SD=3.3$), $t(44)=-2.39$, $p=.021$.

Data Reduction and Analysis

Quality of Mother-Infant Interaction Data

CIB parent scores were all significantly correlated (see Table 1) in the expected directions. These scores were therefore standardised and summed to generate an overall measure of parenting quality with higher scores indicating higher quality of maternal behaviour. Parental Intrusiveness was reversed. This scale showed good internal consistency (Cronbach's $\alpha=.72$).

Table 1
Correlations Between CIB Parent Subscale Scores (N=46)

	Sensitivity	Intrusiveness
Sensitivity	-	
Intrusiveness	-.61***	
Limit Setting	.87***	-.69***

*** $P<.001$

CIB dyad scores were also significantly correlated ($r=-.82$, $p<.001$). These scores were therefore also standardised and combined to produce an overall score of dyadic interaction quality. The Negativity subscale was reversed. This scale also showed good internal consistency (Chronbach's $\alpha=.81$).

Questionnaire Data

Questionnaire data were inputted to SPSS 21.0 (IBM, 2012) from paper copies twice. Pearson's correlations were calculated for each participant for each

questionnaire in order to ensure data entry was accurate and checked and amended if necessary.

Scoring for the CBQ and SDQ was conducted using SPSS syntax provided by the questionnaire authors and publishers. Scoring for the BRIEF was conducted in Excel 2010 (Microsoft, 2010) using formulae derived from the instructions provided in the scoring manual (Gioia et al., 2000).

Behavioural Data

Behavioural data were analysed using E-Prime 2.0 E-DataAid (Psychological Software Tools, Pittsburgh, PA). Reaction time and accuracy data were extracted.

Accuracy was calculated for the congruent and incongruent conditions separately and defined as the percentage of trials for which a correct response was made. Reaction times were calculated for correct trials only. In order to remove outliers, trials with reaction times of less than 300ms, and those more than 3 standard deviations from the mean were identified and removed. Mean reaction time was then calculated for each participant for each flanker condition. Difference scores for accuracy and reaction times were calculated by subtracting the score for the congruent condition from the score for the incongruent condition.

EEG Data

Following data acquisition, and offline, EEG data were band-pass filtered between 0.1 and 30 Hz and recomputed to an average reference. The continuous EEG data were then segmented into target-locked epochs between -200 and 800 ms relative to stimulus onset.

Spline interpolation was conducted on individual channels as necessary. An average of 3.6% of channels were interpolated for each participant (range=0-8.5% of channels). Independent components analysis was run using the Matlab toolbox FASTER (Nolan, Whelan & Reilly, 2010) and was used to extract stereotyped

artefacts, such as eyeblinks. Epochs were excluded from the analysis if they met any of the following artefact rejection criteria: voltage deviations greater than 175 μ V relative to baseline, a maximum gradient of greater than 150 μ V or activity lower than 1 μ V. Across all participants, an average of 78.5% of trials (range=53.7-95.8%) were retained after filtering and artefact rejection. Participant data was excluded if less than 50% of trials yielded acceptable data; this criterion resulted in the exclusion of six participants. Visual inspection of the ERPs identified one additional outlier with values exceeding 30 μ V. Thus in total seven participants were excluded.

Event Related Potentials

The effect of congruency on three ERP components was investigated. Firstly, the P1 component, an index of early visual responses (Luck, 2005, p11) was investigated across occipital electrodes (65 69 70 83 89 90) between 100ms and 200ms. This was to ensure that any effects observed later in the epoch were not driven by perceptual differences between the conditions. The LPC was defined as occurring between 550 and 800ms and was investigated at left (F3, 27, 28, 34), central (Fz, 5, 12) and right (F4, 116, 117, 123) pools of electrodes at frontal sites, based on Rueda, Posner et al. (2004). Finally, the N2 was investigated time window between 300 and 500ms and investigated at Fz, Cz and Pz electrodes, consistent with Buss et al. (2011).

Results

Attention Network Task

Behavioural Data

Descriptive statistics for behavioural performance outcome measures (reaction time and accuracy) for all participating children are displayed in Table 2. Generally, children performed accurately on the task, responding correctly for 97.2% of congruent and 95.7% of incongruent trials. Conflict effects were calculated by

subtracting scores in the congruent condition (reaction time, accuracy) from scores in the incongruent condition.

Table 2

Descriptive Statistics for Accuracy and Mean Reaction Time: Congruent and Incongruent Conditions, and Conflict Scores (N=46).

	Congruent			Incongruent		
	Mean	SD	Range	Mean	SD	Range
Reaction time (ms)	1022	236	652-1544	1136	306	658-1819
Accuracy (%)	97.2	2.53	90.0-100	95.7	4.42	80.0-100
Conflict Scores:						
Reaction time (ms)	114	115	-32.9-530			
Accuracy (%)	-1.51	3.90	-12.6-6.00			

Confirming the hypothesised congruency effect, reaction times were significantly higher, $t(45)=-6.75$, $p<.001$, and accuracy was significantly lower $t(45)=2.62$, $p=.012$ for the incongruent condition.

Electroencephalogram Data

Difference topographies (mean amplitude in the incongruent condition minus mean amplitude in the congruent condition) are shown in Figure 3 for the entire length of the epoch.

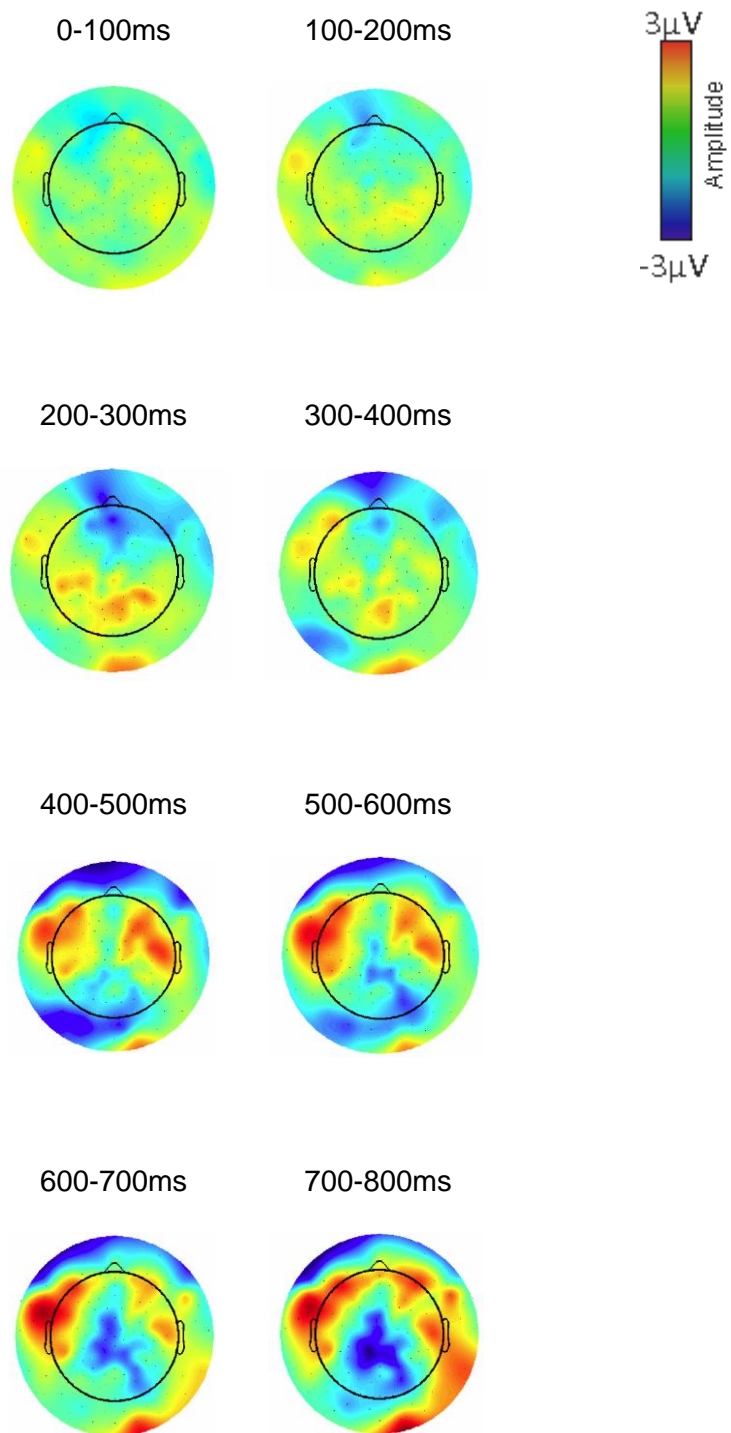


Figure 3: Topographic map of the congruence effect, showing mean amplitude difference between incongruent and congruent conditions across 100ms time periods.

ERPs associated with visual perception and processing

The P1 index of early visual processing across occipital electrodes (65 69 70 83 89 90) between 100ms and 200ms were investigated to ensure there were no

significant differences in visual perception across flanker types. This is shown in Figure 4.

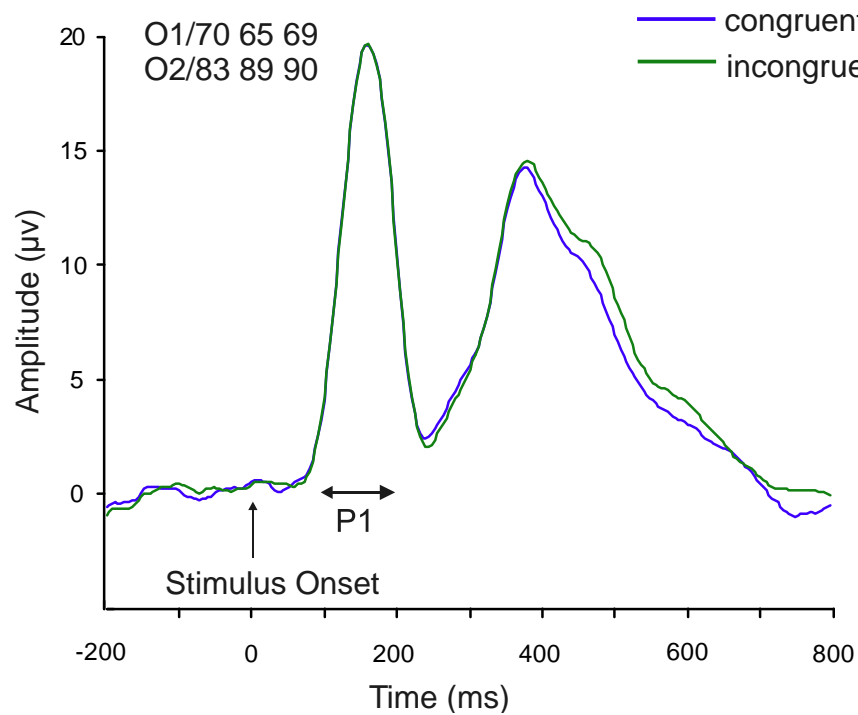


Figure 4: Grand average waveform for P1 component (100-200ms) across occipital electrodes (N=37).

As expected, there was no significant difference between P1 mean amplitude $t(36)=-.18$, $p=.855$ for congruent (Mean=8.03 μ V, SD=4.07) and incongruent (Mean=8.11 μ V, SD=4.43) trials.

Late Positive Component

The LPC was defined as occurring between 550 and 800 ms, and investigated at left (F3, 27, 28, 34) central (Fz, 5, 12) and right (F4, 116, 117, 123) locations based on Rueda, Posner et al (2004): Fz, F3 and F4. Grand average waveforms for these electrodes are displayed in Figure 5. Mean amplitudes are shown in Table 3.

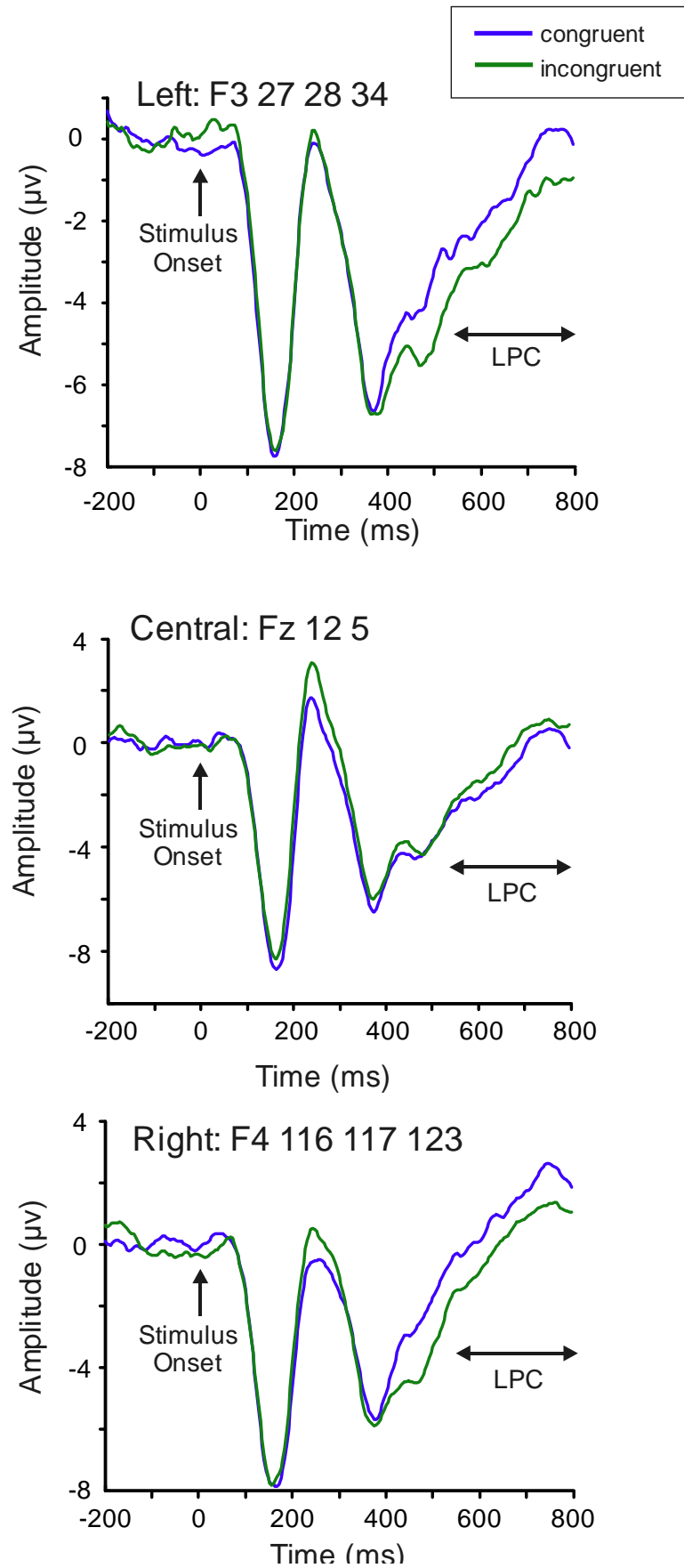


Figure 5: Grand average waveforms at left (F3, 27, 28, 34), central (Fz, 12, 5) and right (F4, 116, 117, 123) locations (N=37). LPC is identified at 550-800ms after stimulus onset.

Table 3

Mean LPC (550-800ms) Amplitudes at Left (F3, 27, 28, 34), Central (Fz, 5, 12) and Right (F4, 116, 117, 123) Locations (N=37).

Electrode	LPC mean amplitude (μ V)		t (p)	df
	Congruent	Incongruent		
Left	-1.04 (3.93)	-2.06 (3.65)	1.95 (.059)	36
Central	-0.87 (5.36)	-0.343 (5.58)	-0.75 (.456)	36
Right	1.26 (3.59)	.239 (4.04)	2.50 (.017)	36

A 3 (Location: Left, Central, Right) x 2 (Trial type: Congruent, Incongruent) repeated measures ANOVA was conducted to determine whether amplitudes varied across sites and trial types. The analysis revealed a significant effect of site $F(2, 35)=5.88$, $p=.004$, $\eta^2_p=.14$. Post-hoc, Sidak corrected, comparisons revealed that mean amplitude at right scalp locations was significantly more positive than left scalp locations. There was no significant main effect of congruency, $F(1, 36)=1.61$, $p=.212$, $\eta^2_p=.043$. There was a significant site x congruency interaction, $F(2, 35)=3.50$, $p=.036$, $\eta^2_p=.089$. Post-hoc, Sidak adjusted comparisons were used to probe the site x congruency interaction. These comparisons revealed a significant effect of congruency at the right location, $F(1, 36)=6.24$, $p=.017$, $\eta^2_p=.15$, but not at the left $F(1, 36)=.3.80$, $p=.059$, $\eta^2_p=.095$, or frontal, $F(1, 36)=.57$, $p=.456$, $\eta^2_p=.02$ sites. The difference between mean amplitude in the congruent and incongruent conditions at each location is shown in Figure 6. This shows that the mean amplitude conflict scores appear comparable for the left and right locations, however there is greater variability in the scores for the left location.

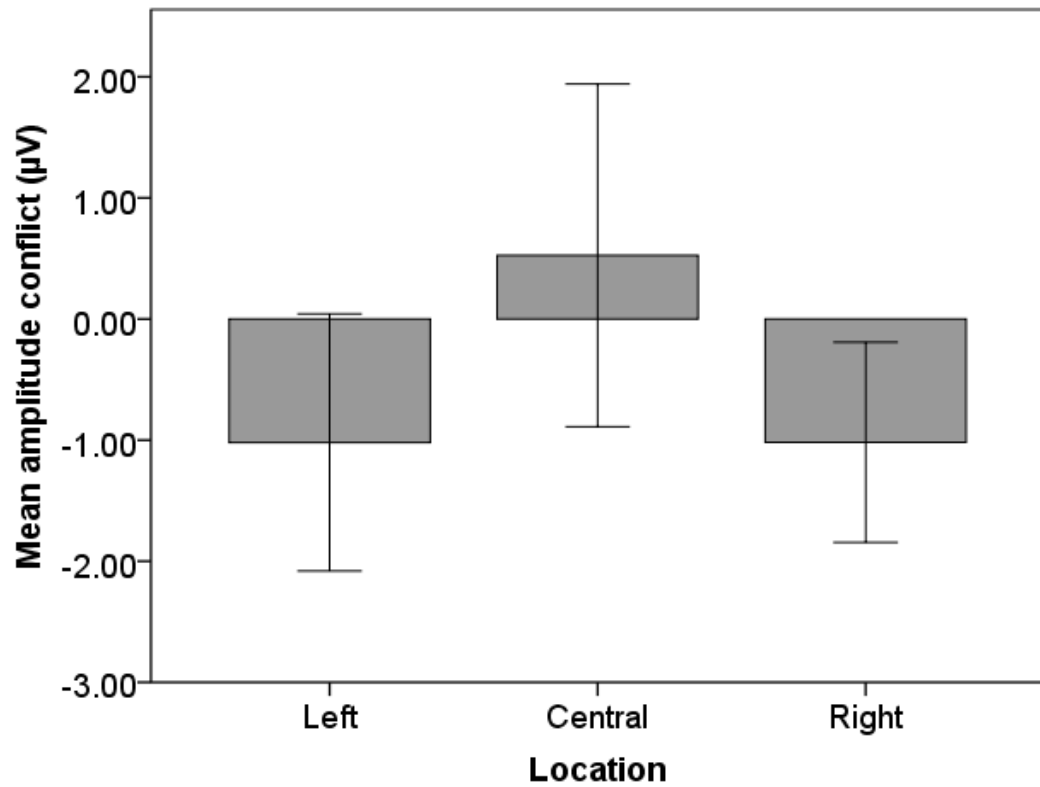


Figure 6: Conflict scores for LPC mean amplitude (550-800ms) at left (F3, 27, 28, 34), central (Fz, 5, 12) and right (F4, 116, 117, 123) locations (N=37).

N2 Component

N2 was defined as 300-500ms in accordance with previous research (Johnstone & Galletta, 2012; Rueda, Posner et al., 2004), and analysed at Fz, Cz, Pz consistent with Buss et al. (2011). Grand average waveforms at these locations are shown in Figure 7. Mean amplitudes and comparison across flanker conditions are shown in Table 4.

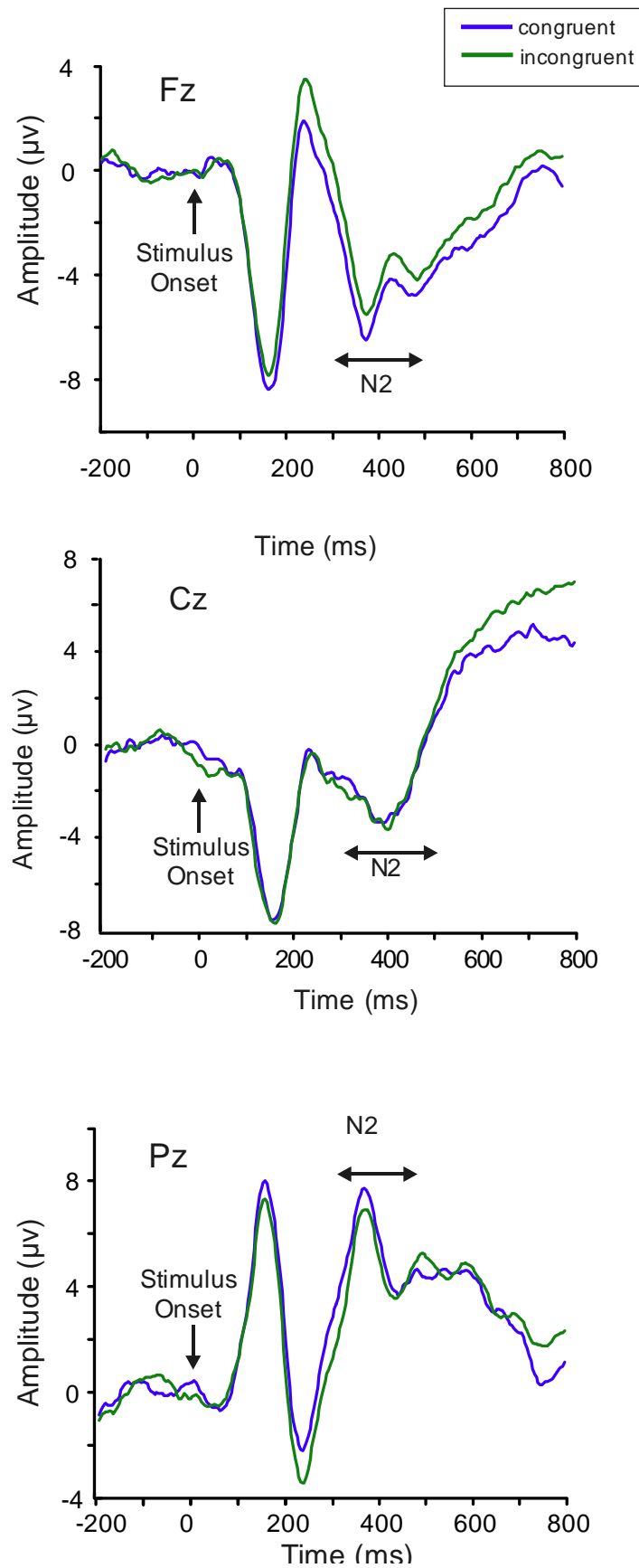


Figure 7: Grand average wave forms at Fz, Cz and Pz ($N=37$). The N2 component is identified at 300-500ms.

Table 4

Mean N2 (300-500ms) Amplitude at Midline Electrodes (N=37)

Electrode	N2 mean amplitude (μV)		t (p)	df
	Congruent	Incongruent		
Fz	-4.52 (5.27)	-3.55 (4.980)	-1.34 (.187)	36
Cz	-1.96 (4.64)	-2.04 (5.27)	.089 (.441)	36
Pz	5.10 (5.30)	4.57 (6.03)	.780 (.930)	36

A repeated measures ANOVA was conducted to determine whether N2 amplitudes varied across sites and trial types. This 3 (Site: Fz, Cz, Pz) by 2 (Trial type: Congruent, Incongruent) ANOVA revealed a significant effect of site, $F(2, 35)=22.8$, $p<.001$, $\eta^2_p=.57$. Post-hoc, Sidak adjusted pairwise comparisons revealed that amplitudes at Pz were significantly more positive than at Fz and Cz. There was no significant effect of trial type $F(1, 36)=.052$, $p=.821$, $\eta^2_p=.001$ and no site by trial interaction $F(2, 35)=1.08$, $p=.352$, $\eta^2_p=.058$.

Effects of Age and Gender

Amongst the conflict mean amplitudes (incongruent – congruent), there were no significant effects of age and gender.

Associations Between ERP and Behavioural Data.

ERP conflict scores were calculated for the LPC and N2 by subtracting mean amplitude in the congruent condition from mean amplitude in the incongruent condition. Descriptive data for these conflict scores are shown in Table 5.

Table 5

Mean Amplitude Conflict Scores for LPC and N2 Components (N=37).

Component: location		Conflict score, mean amplitude	
		Mean (SD)	Range
LPC	Left	-1.02 (3.18)	-8.33 – 6.75
	Central	0.53 (4.24)	-6.34 – 11.5
	Right	-1.02 (2.48)	-6.83 – 4.32
N2	Fz	0.97 (4.40)	-6.35-14.5
	Cz	-0.071 (4.89)	-13.4-10.2
	Pz	-0.54 (4.18)	-7.31-8.76

Correlations between performance scores and ERP conflict scores are shown in Table 6. There were no significant correlations between mean amplitude conflict scores and behavioural performance.

Table 6

Correlations Between LPC and N2 Mean Amplitude and Conflict Behavioural Scores (N=37).

Component: location		Reaction Time	Accuracy
LPC	Left	.009	-.19
	Central	-.16	.050
	Right	-.027	-.038
N2	Fz	-.10	.012
	Cz	-.048	.12
	Pz	-.20	.11

Relations to Parent Report Measures

Descriptive statistics for all parent-report and behavioural outcome measures are displayed in Table 7.

Table 7

Descriptive Data: Demographic, Parenting, Parent-Report and Behavioural Measures.

	Mean	SD	Range
N (% male)	46 (52.2)		
Age (months)	73.1	2.64	69.0-81.0
<i>Parenting</i>			
Maternal behaviour	0	2.71	-6.12 – 4.68
Dyadic Interaction	0	1.91	-4.94 – 2.39
<i>Questionnaires</i>			
Effortful Control	5.74	0.56	3.78 – 6.72
BRIEF Inhibit	51.5	8.70	36.0-78.0
SDQ Hyperactivity/Impulsivity	3.17	2.51	0.00-10.0
<i>Behavioural</i>			
Reaction Time Conflict Score (ms)	114	115	-32.9-530
Accuracy Conflict Score (%)	-1.51	3.90	-12.6-6.00

Relations Between Parent-Report Data and Behavioural Performance

Correlations between reaction time and accuracy conflict effects and questionnaire data are shown in Table 8. Age at follow up testing did not correlate significantly with any of the study variables (reaction time and accuracy conflict scores, CBQ effortful control and SDQ hyperactivity/impulsivity). Parent-report measures were highly significantly correlated with each other. However, correlations with behavioural performance did not reach significance.

Table 8

Correlations Among Scores for Conflict Behavioural Scores and Parent-Report Measures (N=46).

	Outcome Variables				
	1	2	3	4	5
1.Reaction Time Conflict	-				
2.Accuracy Conflict	-.21				
3. Effortful Control (CBQ)	-.063	-.036			
4.Inhibitory Control (CBQ)	.11	-.18	.75***		
5. BRIEF Inhibit	-.041	.092	-.51***	-.62***	
6. SDQ H/I	.21	.018	-.65***	-.70***	.56***

* p<.05, **p<.01, ***p<.001 Two-tailed tests.

Relations Between Parent-Report Measures and EEG Conflict Mean Amplitude

Correlations between the conflict mean amplitude (difference in mean amplitude in the congruent and incongruent condition) and parent-report measures are shown in Table 9. There were no significant correlations between variables.

Table 9

Correlations Between Parent-Report Measures and Conflict Mean Amplitudes.

Component	Location	Effortful Control (CBQ)	Inhibit (BRIEF)	H/I (SDQ)
LPC	Left	.063	.12	.055
	Central	.060	.073	-.12
	Right	.088	.16	.031
N2	Fz	.072	-.056	-.095
	Cz	.061	.040	-.27
	Pz	-.11	.010	-.11

Effects of Parenting

Relations Between Parenting and Behavioural and Parent-Report Measures

Pearson's correlations between maternal behaviour and dyadic Interaction (predictor variables) and the behavioural and questionnaire outcome variables are shown in Table 10. The association between maternal behaviour and parent-reported effortful control was on the threshold of significance. There were no significant correlations between the other measures.

Table 10

Correlations Between Maternal Behaviour and Dyadic Interaction and Behavioural and Parent-Report Outcome Measures (N=46).

	Maternal Behaviour	Dyadic Interaction
Reaction Time Conflict	.073	-.031
Accuracy Conflict	.11	.20
Effortful Control (CBQ) ^a	.29^a	.043
BRIEF Inhibit ^b	.079	.18
SDQ H/I ^a	-.014	.040

^a p=.05

Relations Between Parenting and Conflict Mean Amplitudes.

Correlations between conflict mean amplitudes and quality of care variables (maternal behaviour and dyadic interaction) are shown in Table 11. The LPC conflict mean amplitude on the right was not associated with higher quality of maternal behaviour and dyadic interaction. There were no significant correlations between the variables.

Table 11

Correlations Between Quality of Care and Conflict Mean Amplitudes (N=37).

Component:	Location	Maternal Behaviour	Dyadic Interaction
LPC	Left	.18	.031
	Central	.071	-.078
	Right	.17	-.10
N2	Fz	.023	-.12
	Cz	-.014	.018
	Pz	.060	.17

Discussion

This study aimed to investigate child effortful control using behavioural performance and underlying neural indices of the Attention Network Task, and parent-report measures. It then sought to investigate the relationship between these measures and early observed quality of maternal care, defined as the quality of maternal behaviour and dyadic interaction. This discussion considers the empirical findings of this paper, and relates these findings to the current literature and the research hypotheses. Limitations and alternative explanations are then discussed. The paper concludes with recommendations for future research.

Attention Network Task

Behavioural Task Performance

Consistent with previous research (e.g. Rueda, Posner et al., 2004), there was a significant effect of flanker type on task performance. Mean reaction times were slower for incongruent trials, and accuracy was reduced for incongruent trials. Overall, response accuracy was higher, and reaction times faster than observed in

Rueda, Posner et al. (2004); this likely due the increased age in the current sample. The conflict score for reaction times, calculated by subtracting the overall mean of mean reaction times in the congruent condition from the incongruent condition ($M=114\text{ms}$), was comparable to that of Rueda, Fan et al., (2004) in children aged six, who report a mean conflict effect on reaction times of 115ms. The conflict effect for response accuracy in this sample was, however, an order of magnitude smaller than recorded in Rueda, Fan et al. (2004); 1.5% compared to 15.6% respectively. This may be explained by the longer response time allowed in the current study: 5000ms versus 1700ms in Rueda, Fan et al. (2004).

Electroencephalogram Data

Data Quality

Data from thirty-seven children was included in the final EEG analysis, representing 84% of the sample for whom EEG was available. Data is therefore available for a larger sample size than Buss et al. (2011) with an N of 26, and Rueda, Posner et al. (2004) with an N of 14. It is comparable to Rueda et al (2012) which reports an N of 36, however the sample was split and half the children received training in that study, such that limited data was available for the full group pre-training. In the current study, an average of 78.5% of trials (range=53.7-95.8%) was included for each child. This exceeds the 53.2% of trials included in Rueda, Fan et al. (2004), which may be explained by the slightly older sample reported here. The average number of channels interpolated for this study was 3.61%, substantially lower than the 7.56% reported by Buss et al. (2011). This study thus reports data from a good sample size for an EEG study, with a large number of included trials. The data appears to be of good quality, as demonstrated by a lack of noise in the grand average waveforms and little variation between amplitude in the congruent and incongruent conditions where this is not expected. Indeed, analysis of the P1 component across occipitally located electrodes indicated no

significant differences between the congruent and incongruent conditions. This confirms no significant visible differences between congruent and incongruent stimuli, and good data reliability between the two conditions.

ERP Components

Late Positive Component

The LPC was investigated between 550 and 800ms at three clusters of electrodes at frontal locations: left (F3, 27, 28, 34), central (Fz, 5, 12) and right (F4, 116, 117, 123), based on Rueda, Posner et al. (2004). For this component there was a significant site x trial type interaction $F(2, 35)=3.50$, $p=.036$, $\eta^2_p=.089$. Sidak corrected post-hoc comparison identified a significant effect of trial type at the right (F4, 116, 117, 123) $F(1, 36)=6.24$, $p=.017$, $\eta^2_p=.15$, indicating a moderate effect of congruency on mean amplitudes at the right frontal location. The effect at the left frontal location (F3, 27, 28, 34) did not reach significance, but indicates a trend towards significance, $F(1, 36)=3.80$, $p=.059$, $\eta^2_p=.095$ consistent with the effect on the right. There was no significant effect of congruency at the central (midline) frontal site (Fz, 5, 12). Rueda, Posner et al. (2004) also found an effect of trial type on peak amplitude for this component, and note that this occurred at frontal midline and lateral electrodes (Fz, F3, F4) although further statistics regarding the specific location were not provided. The LPC has also been shown to be more positive in No Go trials during a Go No-Go task in children aged six (Davis et al., 2003), although this effect was not lateralised, being significant at Fz and not F3 and F4. Rueda, Posner et al. (2004) argue that their study, and the work of Davis et al. (2003), indicate that the LPC reflects conflict monitoring in children. The findings in the current study are consistent with this suggestion, albeit localised more laterally than has previously been demonstrated. It has also been proposed that the LPC reflects attention resource allocation (Polich, 2007). The significant effect of congruence on mean amplitude identified in the current study is consistent with this

proposal; greater attentional resources are required when the target occurs in the presence of distracting (incongruent) flankers.

The frontal location, the time window within which the effect occurs, and the wave morphology imply that this component is indeed best explained as the LPC. Classically, however, the LPC component is defined as the amplitude change over midline electrodes (Polich, 2007) rather than laterally. Further investigation and replication of these data would confirm whether more lateralised effects are commonly seen in children during Attention Network Task performance. This is certainly a possibility, given the consistency of findings between the current study and Rueda, Posner et al (2004). The findings support the first study hypothesis that there would be a significant effect of congruency on the mean amplitude of the LPC component.

N2 Component

With respect to the N2 component, defined as occurring 300-500ms post stimulus onset across midline electrodes (Fz, Cz and Pz) no significant effects of trial type or site x trial type interactions were found. This is consistent with Rueda, Posner et al. (2004) who found no effect of trial type on N2 peak amplitude in their sample of four year-olds, although these authors investigated the N2 at the FCz midline and Fc3 and Fc4 lateral sites (although these locations were not investigated in this sample to minimise the likelihood of Type 1 errors). Buss et al. (2011) identified significantly greater N2 amplitudes in the incongruent condition at the Cz electrode, in the older half of their sample: children aged six to eight years (N=12). This effect at Cz was not replicated in Rueda et al (2012). Given the relatively large sample size and data quality in the current study, and the consistent findings with Rueda, Posner et al (2004) and Rueda et al (2012) it seems reasonable to infer that a congruency effect for the N2 component is not reliably elicited by the Attention Network Task in children aged six years.

Effects of Age and Gender

Buss et al. (2011) identified effects only in older children, however no significant effect of age was found for any component in the current study. This may be due to the substantially smaller age range of the sample. Children in the current sample were aged between five years nine months to six years nine months, rather than four to eight years in the Buss et al. (2011) sample. In the current study, no main or interaction effects involving gender were statistically significant.

Relations to Behavioural Data

This study hypothesised that EEG neural indices of conflict/inhibition during the executive attention component of the Attention Network Task would be associated with individual differences in behavioural task performance.

With regards to the LPC, there were no significant correlations between conflict mean amplitude and reaction time or accuracy conflict scores. This is not consistent with the hypothesis, and there may be a number of explanations for this. Firstly, since a behavioural response arises as a consequence as a number of cognitive processes, it may be that the effect of congruency is driven by other processes which are not captured by the LPC. Alternatively, it may be that the relationship between the LPC and behavioural performance cannot be discerned due to individual variation in EEG amplitudes which reduces the likelihood of detecting small effects. In addition, with regards to accuracy, the overall proportion of correct responses was high, and ceiling effects may thus have reduced the sensitivity of this measure to individual differences in conflict effects. Finally, the lack of significant association identified may be a consequence of low power. Notably, however, the sample size reported here is not dissimilar to other studies of its kind.

With respect to the N2 component, conflict mean amplitude did not correlate significantly with reaction time or accuracy conflict scores. Rueda, Posner, et al.

(2004) also did not report any significant association between task performance conflict effects and amplitude effects for the N2 component. The findings are, however, in contrast to Buss et al. (2011), who reported a significant correlation between peak amplitude conflict effects for the N2 component at Cz and reaction time conflict scores, using partial correlations controlling for age.

There may be several explanations for this difference between findings here and the work of Buss et al. (2011). Firstly, the effects identified by Buss et al. (2011) may well emerge later than the age of the children in this current sample, where the mean age is 73 months. Secondly, given that no significant effects of trial type were found here, it is perhaps to be expected that that conflict effects of mean amplitude do not correlate with parent-reported effortful control. Thirdly, it is possible that the significant association identified by Buss et al. (2004) represents an artefact in the data, since the sample size was very small and the results were not replicated by Rueda, Posner et al. (2004). Finally, and in contrast, the lack of significant association in the current study may be a consequence of the sample size and insufficient power to detect an effect.

Parent-Report Measures

Correlations between parent-report questionnaires indicated substantial and significant associations between these measures. Some of these relationships, for example between the CBQ effortful control factor and inhibitory control subscale, indicate the internal consistency of the questionnaire (indeed the inhibitory control subscale contributed to the effortful control factor).

There were significant negative correlations between CBQ effortful control and the BRIEF Inhibit subscale, and between the CBQ inhibitory control and the BRIEF Inhibit subscale and Behavioural Regulation Index. These associations have been previously demonstrated in younger children using the BRIEF Preschool Version (Cuevas, Hubble & Bell, 2012; Espy, Sheffield, Wiebe, Clarke & Moehr,

2011). This appears to be the first study investigating the relationship between these two measures in an older sample using the BRIEF questionnaire designed for school aged children.

Similarly, the SDQ hyperactivity/impulsivity subscale correlated significantly with all other parent-report measure scales, in the expected direction. This is consistent with previous associations between the two measures found in slightly older children aged seven to nine years (Schlotz, Jones, Godfrey & Phillips, 2008) and in somewhat younger children, aged three years (Gusdorf, Karreman, van Aken, Deković & van Tuijl, 2011).

Relations Between Behavioural and Parent-Report Measures

The third study hypothesis was that smaller conflict effects of reaction time and accuracy (the difference between the congruent and incongruent conditions) would be associated with higher levels of parent-reported effortful control. No significant correlations were found between conflict effects in behavioural task performance (reaction time and response accuracy) and parent-reported effortful control, inhibitory control or hyperactivity/impulsivity. These results do not support the hypothesis. This is contrary to the findings of Checa et al. (2008) who tested 69 12 year olds and Simonds et al. (2007) in 49 children aged seven to ten years. The lack of significant association in the current study may be the consequence of the sample size and insufficient power to detect an association, although the samples sizes here are not incomparable to the previous studies. It is also possible that the difference in findings may be explained by the younger age of the current sample. With respect to response accuracy, this lack of association may also be a consequence of a lack of sensitivity due to large numbers of the sample performing at the test ceiling.

In addition, with respect to the BRIEF questionnaire, there is some evidence to suggest that parent- and teacher-reports may not correlate significantly with

behavioural performance on assessment tasks of executive function. For example, McCauley, Chen, Goos, Schachar and Crosbie (2010), compared behavioural performance on a stop-signal task, considered a measure of inhibitory control with BRIEF Behaviour Regulation Index scores in a mixed sample of clinic-recruited and typically developing control children and did not find a significant association. It may be that a clinical measure is, by design, less sensitive to variation within the typically developing child population.

Relations Between EEG Data and Parent-Report Measures

The study hypothesised that neural indices of conflict/inhibition would also be associated with individual differences in parent-reported effortful control. No significant correlations were found between the mean amplitude conflict scores and parent reported effortful control on the CBQ, parent-reported Inhibition on the BRIEF, or parent reported hyperactivity/impulsivity on the SDQ. The hypothesis is therefore not supported.

As with associations with behavioural data, these findings do not replicate the work of Buss et al. (2011), who found that N2 peak amplitude at Cz for incongruent trials, and the conflict effect of peak amplitude (incongruent – congruent) correlated significantly with parent-reported effortful control. As discussed above, this lack of replication may be due to the younger age of the current sample, the very small sample size of Buss et al. (2011) resulting in a statistical artefact, or the small sample size in the current study resulting in insufficient power.

Relation to Maternal Behaviour and Dyadic Interaction

Relations Between Parent-Reported Effortful Control and Parenting

The association between Maternal Behaviour, a composite of maternal sensitivity, negativity and limit-setting and parent-reported effortful control on the

CBQ questionnaire ($r=.29$) was on the threshold of significance, since $p=.05$. This is a potentially interesting finding, since it is consistent with the second hypothesis of the study. However it would require replication in a larger sample since the commonly accepted threshold for statistical significance was not exceeded. No other associations between Maternal Behaviour and parent-report questionnaire measures approached significance. There were also no significant associations between the quality of dyadic interaction and parent-report measures.

The study hypothesised that higher quality of maternal behaviour during mother-infant interaction, and the quality of dyadic interaction would be associated with both parent-reported effortful control and individual differences in conflict performance on the Attention Network Task. This hypothesis was supported with respect to maternal behaviour and effortful control as assessed using the CBQ, the parent-report measure most directly related to effortful control. For measures less directly measuring effortful control (BRIEF and SDQ), and correlations with dyadic interaction, which assesses both maternal and infant behaviour, there is less support for the hypothesis.

As discussed in the introduction to this paper, there are numerous studies evidencing a significant association between both maternal care and effortful control (e.g. Eisenberg et al., 2003, Mintz et al., 2011) and the quality of parent-infant relationship (e.g. Feldman et al., 1999; Kochanska et al., 2008; Li-Grining, 2007). However, the meta-analysis conducted for Volume 1 of this thesis (Carman, 2013) similarly identified a number of papers which did not report significant findings. For example, Karreman, van Tuijl, van Aken & Dekovic (2008) found no significant correlations between either parent-reported effortful control and observed maternal warmth or negative control in their sample of 89 children aged three. Similarly, in a larger sample of 214 older children, aged eight to twelve years, Kiff, Lengua and Bush (2011) found only a small significant correlation between effortful control and maternal warmth, and no association with maternal negativity, autonomy granting or

guidance and structure. Overall, the meta-analysis identified a small (although highly significant) overall effect size and substantial variation in effect sizes found in the literature for the association. Thus the lack of significant association identified here may well be due to a lack of power to detect a small effect. This is discussed further below.

Relations Between Behavioural Task Performance and Parenting

No significant associations were noted between conflict effects of behavioural task performance (reaction time and accuracy) and either maternal behaviour or dyadic interaction. It was hypothesised that a reduced conflict effect on Attention Network Task performance would be associated with higher quality of maternal behaviour and dyadic interaction. This hypothesis is not supported by these results.

As discussed, there is little previous research investigating computerised assessments of effortful control and their relations to parenting. Belsky et al. (2007) found a significant association between Continuous Performance Test (CPT) of attention regulation and maternal sensitivity in children of a similar age. However, their data was drawn from a much larger study of over a thousand children. Again, the lack of significant association identified in this study may be a consequence of the small sample size. In addition, it has been argued that the CPT is more an assessment of sustained attention and impulsivity, rather than effortful control (Halperin et al., 1991) and thus comparison between a study using this measure and the current study may not be appropriate.

Relations Between EEG Indices and Parenting

The current study's final hypothesis was that the quality of early parent interaction would be associated with the EEG indices of effortful control, specifically the LPC. There were, however, no significant correlations between ERP mean

amplitude conflict effects and Maternal Behaviour or quality of Dyadic Interaction. The hypothesis is therefore not supported by the data here. This hypothesis was predicated on previous study hypotheses which speculated that ERP components related to behavioural task performance and parent-reported effortful control, and that these related to Maternal Behaviour and Dyadic Interaction. Given the lack of association between ERP components and behavioural task performance and parent-report measures of effortful control, this finding is, perhaps, unsurprising.

Strengths and Limitations

Design

The longitudinal design of the study is a strength, as it facilitated investigation of the same group of children over time and the assessment of the relations between early experiences and later abilities. Researchers were blind to the original data collected at age ten months. These factors contribute to good internal validity.

However, the sample size is a substantial limitation which has potentially impacted significantly on the power of the study to detect effects. Participants for the study were drawn from an original cohort recruited five years previously, and there hence existed only a finite number of families from which the sample could be drawn. Attrition was also quite high, as a consequence of families moving away, having additional demands on time, such as the birth of new siblings or due to contact details no longer being accurate. Nevertheless, retention rates were not incomparable to other reports in the literature of similar longitudinal studies (e.g. Cipriano & Stifter, 2010; Olson, Bates, Sandy, & Schilling, 2002).

With respect to the hypotheses regarding the associations between early quality of care and the development of effortful control, it is likely that the effect size used in the power calculations represented an overestimate. This is in light of the new information provided by the meta-analysis reported in the first Volume of this

thesis (Carman, 2013), which places the estimate of effect size around $r=.16$. Accordingly, the power analysis is likely to have underestimated the necessary sample size to detect an effect, and significant associations between parenting and effortful control might not be expected in a study of this size. This was not the case for maternal behaviour and parent-reported effortful control on the CBQ, where $p=.05$ for the association, however the significance of other associations may well have been impacted detrimentally by the study's lack of power.

Looking to the EEG section of the study, sample sizes are comparable to, or exceed the sample sizes of previous studies (e.g. Buss et al, 2011; Rueda, Posner et al., 2004). Indeed, sample sizes in the neurosciences tend to be smaller, and in their recent review, Button, Ioannidis, Mokrysz, Nosek, Flint, Robinson et al. (2013) argue that this both reduces the chances of detecting a true effect, and increases the chances that statistically significant results do not reflect a true effect. Consequently, results of the current study, both non-significant and statistically significant, should be interpreted with caution, and require replication and investigation using a larger sample, for confirmation of true effects.

Sample

The homogeneity of the study sample is a further potential limitation. The children are drawn from relatively wealthy, well-educated, Caucasian families. There is evidence to suggest reduced conflict effects in socioeconomically advantaged children (Mezzacappa, 2004). This could have reduced the sensitivity of the measure to detecting differences in performance. There is also a detrimental impact on generalizability; it is unclear whether the findings of this study would also relate to children at socioeconomic disadvantage or of different ages and ethnic origins.

Measures

There were a number of strengths to the measures used in the study. Firstly, the assessment of parenting was conducted using observation methods, considered to be more reliable than self-report measures (Morsbach & Prinz, 2006; Perepletchikova & Kazdin, 2004). Secondly, assessment of effortful control utilised both well-established parent-report measures and an objective behavioural task measure. However, whilst the BRIEF questionnaire is a well validated clinical measure for the assessment of executive function difficulties, it is perhaps a limitation that this may render it less sensitive to variation amongst a typically developing, normative sample, and there is some evidence of a lack of correlation with behavioural measures (e.g. McCauley et al., 2010).

With respect to the Attention Network Task, a potential limitation with the performance data is the very high level of accurate responses made by the children in the sample. This may have resulted in ceiling effects, reducing the sensitivity of the measure to detect effects of conflict on task performance. This, however, represents a trade-off, since only correct trials can be included in EEG analysis.

In addition, whilst the well described behavioural properties of the Attention Network Task are a clear strength and advantage, the underlying neural correlates of task performance have not received the same degree of research scrutiny. Limitations to the previous studies investigating ERPs associated with performance include small sample sizes and a lack of consistency in data analysis procedures and results. Accordingly, a further potential limitation of the current study in terms of the investigation of associations between early quality of care, task performance and neural correlates is the lack of replication amongst previous research findings. Whilst the extant literature identifies appropriate EEG component targets for investigation, and appears consistent with the findings of the current study, the potential for verification of these findings is somewhat limited. The advantage, however, is that this study is able to provide a contribution to the existing literature

regarding the neural indices of Attention Network Task performance in children aged six years.

With respect to the N2 component, the results for the current sample are consistent with expectations; in younger children there does not seem to be a significant effect of flanker type. This component was, however, demonstrated to be associated with effortful control in older children by Buss et al. (2011). Using a Go No-Go task, No-Go N2 effects have been demonstrated in children aged 6-7 (Jonkman, 2006) and behavioural performance on Go No-Go tasks has been associated with parent-reported effortful control in four year olds (Jones, Rothbart & Posner., 2003). It would be interesting to investigate the relationship between the N2 effect and parenting, and a Go No-Go task may provide a more useful assessment tool in children of this age.

Summary, Conclusions and Recommendations

This study primarily aimed to investigate the relations between parent-report and objective behavioural assessment of effortful control and observed quality of care, as defined by maternal behaviour during interaction and dyadic interaction quality. The results of the study do not indicate an association between these variables, however this is likely due to the small sample size and resulting lack of power.

This study also aimed to investigate neural indices of behavioural performance on the Attention Network Task. Using a larger sample size than has previously been reported, and with data which has a high signal to noise ratio, this study has identified two key findings. Firstly, there appears to be an effect of trial type on the LPC at frontal locations. The significance of the effect is restricted to the right lateral location in the current study however data for the left trended towards significance. These results indicate that LPC index of conflict monitoring may be lateralised, rather than occurring at the midline as has previously been proposed. Secondly, the study has demonstrated that children aged six do not show effects of congruency on

the N2 component. This contributes to the growing body of literature suggesting that this effect is seen only in older children.

As a consequence of the study findings, suggestions for future research investigating the neural indices of effortful control, and their relation to early experiences of parenting are described below:

1. Replication to confirm the lateralised LPC effect is recommended. If confirmed, this effect may serve as an important target of investigation for determining the neural processes underpinning the development of effortful control during early childhood.
2. Further investigation regarding the age at which the N2 index of cognitive control or response inhibition emerges will inform understanding of the neural processes contributing to the development of this ability.
3. Comparison of the N2 and LPC indices in samples of children at known risk for reduced effortful control such as children with ADHD, children born preterm or a at very low birth weight and children subject to early abuse and neglect may further understanding of the developmental psychopathology of these difficulties.
4. More detailed investigation of the nature of the relationship between EEG indices, behavioural measures and parent-report data is recommended, using a larger sample size, to determine the how performance of these more objective measures is related to developmental behavioural outcomes and explore their ecological validity.
5. Further empirical evaluation of the associations between early experiences of parenting and the neural indices of effortful control using a larger sample size is recommended to investigate whether an association is discernible in a study of sufficient power.

6. Given the homogeneity of the sample of children in terms of age, ethnicity and socioeconomic status, replication with a more diverse sample would also be important to determine the generalizability of the findings.

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Part 3: Critical Appraisal

The aim of this thesis was to investigate the role of parenting in the development of effortful control. This appraisal sets out my reflections on the research process, in the context of my own personal approach to, and understanding of research. Firstly, the concepts investigated in the meta-analysis and empirical study are considered, followed by a discussion of the notion of objectivity in psychology research, and how this relates to the methodologies used. The pragmatic issue of recruitment and sample size is then reviewed, with some discussion of guidelines for future research. The appraisal concludes with a brief discussion of the clinical utility of the research findings.

Personal Context of Research

“A scientist ... puts forward statements, or systems of statements, and tests them step by step. In the field of empirical sciences, more particularly, he constructs hypotheses, or systems of theories, and tests them against experience by observation and experiment.”

Popper (1935/2005)

At the beginning of the research process, my view was consistent with this definition offered by Popper (1935/2005). Likely as a consequence of my background in Natural Sciences, my preference was for a positivist approach and quantitative, hypothetico-deductive research. That is, I generally held the idea that human abilities and behaviour can be defined and measured and empirical investigation used to further our understanding of how these abilities and behaviours develop. Conducting the thesis research has highlighted some of the challenges of this approach at both the definition and measurement stages.

Conceptualisation: Defining Psychological Constructs

Effortful control

Towards the very beginning of the thesis, the idea of conceptual overlap between the terms 'effortful control,' 'executive attention' (Rothbart, Sheese & Posner, 2007), 'executive function' (Zhou, Chen & Main, 2012) and 'self-regulation' (Karreman, van Tuijl, Van Aken & Dekovic, 2006) was introduced. This posed challenges for defining the search terms and inclusion criteria of the meta-analysis, for. To address these challenges, I chose the following view, described below.

Firstly, consistent with the work of Posner, Rothbart and colleagues (e.g. Rothbart, Posner & Kieras, 2006; Rothbart et al., 2007; Rueda, Posner & Rothbart, 2005) executive attention was treated as the cognitive and neural underpinning of effortful control. Secondly, as proposed by Diamond (2013), executive attention was considered to be synonymous with inhibitory control of attention. This is considered a particular manifestation of the wider ability of inhibitory control which also includes response inhibition (inhibition at the level of behaviour). Finally, effortful control was conceptualised as one of an array of abilities which together constitute self-regulation. To me, this represented a compromise between implementing too narrow a definition of effortful control, at the cost of neglecting studies investigating highly related, possibly equivalent, abilities, and too broad a definition where studies of related but not equivalent abilities (such as compliance) were included.

There are likely to be, however, criticisms to this approach. Particularly with respect to executive function, where there remains discussion in the literature as to whether this is better conceptualised as a unitary construct or as a set of dissociable components (for reviews see Best & Miller, 2010; Diamond, 2013, Zhou et al., 2012). In addition, it could be argued that standard behavioural assessment batteries and cognitive tasks neglect some key aspects of effortful control, as assessed by the CBQ (Rothbart, Ahadi, Hershey, & Fisher, 2001), such as perceptual sensitivity and low-intensity pleasure.

Considering the concept of effortful control and its relations to these other constructs led me to reflect upon how so many inter-related terms and concepts had arisen. It seemed that there may be two key possibilities to explain this. On the one hand, each concept may represent differing interpretations of the same underlying ability, defined with subtle differences as a consequence of differing theoretical or methodological orientations. This explanation certainly seems to offer a more parsimonious account, since a plethora of interpretations seems more likely than multiple dissociable but seemingly similar abilities. In support of this, there does seem to be considerable overlap between the definitions and assessment paradigms of the different constructs, increasing consideration of this in the literature (e.g. Zhou et al., 2012), and calls for greater interdisciplinary investigation (e.g. Henderson and Wachs, 2007).

On the other hand, it is possible that each concept represents a distinct ability, or constellation of abilities, which can be dissociated from others either functionally, neurologically, or both. There is also some evidence for this explanation. For example, the degree of coherence across behavioural tasks, and between behavioural and parent-report measures increases through early development (e.g. Kochanska, Murray and Harlan, 2000, Carson, 2005), although this may equally reflect greater error of measurement of emerging abilities in younger children. In addition, traditional definitions of executive function include abilities such as working memory which are more difficult to reconcile as equivalent to effortful control abilities.

It is likely that both explanations may be partly true; that there does exist a substantial degree of overlap between the constructs defined differently in different research disciplines but that some abilities are also distinct from other. This highlights a challenge to my idea of research as the straightforward process of defining and measuring human abilities and behaviour since this becomes far more

complex when the nature of any definition varies with the theoretical orientation, and the level at which the construct is to be measured.

Effortful control seems to provide a good example of a construct which can be measured at the behavioural, cognitive and, more recently, neurological levels. This also allows investigation of the interfaces and relations between these levels of measurement, as in the empirical paper of this thesis. Indeed, referring to effortful control, Pennington, Snyder and Roberts Jr (2007) describe the collaboration between the cognitive neuroscientist Mike Posner and temperament researcher Mary Rothbart as 'historic,' changing the view that each field had little to offer the other. Henderson and Wachs (2007) further propose that continued integration of these two fields will lead to conceptual and empirical advances in understanding.

Parenting

There exists an even greater multiplicity in constructs and concepts of parenting as for effortful control. The meta-analysis separated constructs along the same lines as other reviews of the relations of parenting to development outcomes (Karreman et al., 2006; Kiff, Lengua and Zalewski 2011; McLeod, Weisz & Wood, 2007; McLeod, Wood and Weisz, 2007); those behaviours related to emotional aspects of parenting, and those relating to limit-setting, structure and guidance. Detailed investigation of the range of different parenting constructs within the two broad aspects of parenting was not possible in the meta-analysis due to variation in the definitions used in the studies.

My impression is that variability in parenting constructs reflects a number of parenting behaviours, both distinct and inter-related, associated with different parenting tasks, for example meeting a child's emotional needs and skills-teaching, as well as differing theoretical interpretations of the same underlying ability. In addition, a vast range of other factors are associated with parenting behaviour. These include, but are not limited to, internal factors such as parental personality,

and external factors such as ethnicity, culture, socio-economic status. These issues are described in detail in the Handbook of Parenting (Bornstein, 2002); full discussion certainly exceeds the scope of this appraisal, but seems well summarised by Papoušek and Papoušek's (2002; p183) description of parenting as *"a complex, multifactorial, and dynamic phenomenon, often too difficult to study without reductionistic restrictions to experimental approaches."*

The substantial complexity of the concept of parenting further highlights the challenges for the 'defining variables' stage of the research process. This is particularly pertinent with respect to the meta-analysis, which recommended further investigation into the specific behaviours which promote such development.

Summary

This section aimed to discuss the challenges of defining complex human behaviour, in the historical context of investigation at different levels and within different fields of psychology. With respect to effortful control, understanding of how these different levels of investigation interrelate is increasing with the growth of interdisciplinary research. For parenting, it is likely continued research attention will give rise to a greater understanding of how specific parenting behaviours are related or distinct and how these impact children's development. Both constructs indicate the continued need for process of describing and defining human behaviour and abilities as a research endeavour in itself, in order to facilitate the subsequent investigation of the associations between these variables.

Measurement: in search of objectivity

This next section considers some of the challenges of measurement. Methodological limitations and the degree of subjectivity in seemingly objective measurement processes are discussed.

EEG methodology

EEG allows the investigation of neural correlates of behavioural task performance and offers excellent temporal resolution. Woodman (2010) argues that this temporal resolution makes the methodology particularly suited to the investigation of attention which equally operates on this temporal scale. Luck (2005, pp21-27) further describes how an ERP can be much more informative than simple reaction time and accuracy scores as it enables investigation of the constituent processes through which a response arises. In addition, with respect to effortful control, EEG methodology allows for investigation and comparison at the interface of different levels of conceptualisation: behavioural (parent report), cognitive (behavioural task performance) and neural (EEG). Free from observer evaluation or rating, and with a clear target of measurement/investigation, EEG methodology seemingly also offers a degree of objectivity which exceeds that of many other approaches. Nevertheless, my experience of the process of gathering and analysing EEG data highlighted a number of limitations and potential sources of subjectivity.

Firstly, with respect to data collection. EEG makes particular demands of research participants to sit very still, focus attention and complete sufficient numbers of trials of a potentially rather boring task to provide adequate data. As noted by DeBoer, Scott and Nelson (2005, p263), this is a lot to ask, particularly of children, and the child's assent is, of course, a fundamental necessity both ethically and in order to complete the assessment session. As one might expect, enthusiasm to participate understandably waned for some children over the course of the testing session and for some children, so did their ability to comply with these requirements. There are two implications of this. Firstly, there is an ethical balance to be found, between encouraging children, once they have begun participating, to provide as good and 'useable' data as possible, in order that their efforts were not in vain, whilst avoiding coercion to participate when they no longer wish to. Scheduled

breaks, swift and efficient net application, a clear indication of how many blocks of trials were still to go and praise for efforts were all helpful in encouraging participation.

There remained, however, a number of cases where we ended the testing session early, did not apply the net at all or were unable to use the data. This raises the second implication of EEG task demands: they may result in a systematic difference between children from whom data of sufficient quality can be readily collected, and those from whom it is not. This is particularly pertinent when the focus of investigation is 'effortful control' as this may well be the temperament trait/ability which facilitates or impedes the ability to sit sufficiently still. This did not appear to be the case for the current study, where excluded children did not differ significantly in terms of parent-report measures, although the numbers of children were very small and it may be that any effect can only be discerned across the field in general.

There are large numbers of papers using EEG methodology with children with ADHD (for a review see Barry, Clarke & Johnstone, 2003). Since data are available for a group of children whom we might, almost by definition, expect to struggle with the EEG task requirements, this may imply that biased sampling of children high in effortful control, whilst a logically valid concern, is not in fact the case in the literature. However, it is possible that even greater numbers of children are excluded in these studies, and more relevant adjustments such as breaks and shorter testing sessions were required. The issue of systematic biases in the children included in studies thus may be not insurmountable, but should certainly be considered both in developing and interpreting research studies.

A second concern is the degree of subjectivity inherent in data preparation and analysis. In order to identify 'bad' channels for interpolation, criteria for what constitutes an artefact are set. Channels are then chosen for interpolation based on the number of epochs for which these criteria are exceeded. Following this process,

any trials where artefact rejection criteria are still exceeded are not included in analysis. There seems an element of subjectivity to the artefact rejection criteria, and to the process of selecting channels to interpolate. Ibanez, Melloni, Huepe, Helgiu, Rivera-Rei, Canales-Johnson et al. (2012) note this limitation and suggest that more meticulous reporting of preprocessing stages would ensure greater comparability and reliability of EEG studies. This is also reiterated in the recording standards and publication criteria produced by Picton, Bentin, Berg, Donchin, Hillyard, Johnson et al. (2000).

Subjectivity can also arise during analysis, when the electrode sites and time windows for investigation must be selected. Given the large number of electrodes and time windows, inflation of Type 1 error and selective analysis which serves to demonstrate the hypotheses of the experiment can be all too easy (Kriegeskorte, Simmons, Bellgowan & Baker, 2009). One approach to reduce these risks, as adopted in the current thesis, is to utilise locations and time windows previously investigated in other comparable studies. However, variations in data between samples can then result in analysis violating the guideline that measurement should not span clearly different ERP components (Picton et al., 2000). In addition, Button, Ionnidis, Mokrysz, Nosek, Flint, Robinson et al (2013) argue that statistical power across neuroscience research is very low and that as a combined consequence of this, and publication bias, the effects identified in previous research may well represent an exaggeration of the 'true' effect size. There may thus be limitations to analysis based on previous research findings.

With regards to interpreting the findings of ERP research, my impression is that whilst substantial progress has been made, there remains much discussion in the literature regarding the underlying processes represented by particular ERP components such as the P3/LPC investigated in the current study (for a review see Polich, 2007). Luck (2005, p23) states that "*some degree of inference is always necessary when interpreting physiological measures of cognition.*" Thus, whilst the

EEG methodology may represent a good means of objective data acquisition, there may remain some degree of subjectivity, or potential for researcher bias, in interpretation of this data.

In summary, it seems that analysis of EEG findings requires a delicate balance of testing *a priori* hypotheses derived from previous investigation with tentative, data-driven exploratory analyses, with necessary caveats for interpretation and correction for multiple comparisons. Transparency in the procedures for data pre-processing, artefact rejection and analysis is clearly also vital (Ibanez et al., 2012; Picton et al., 2000). Through an iterative process of replication, and peer review, consistent findings can be identified and more robust conclusions drawn than for any one particular study in isolation.

Meta-analysis

When my systematic search resulted in a large number of papers, each providing a numerical effect size for the association between parenting and child effortful control, I chose to conduct a meta-analysis. This seemed a more appropriate means of summarising the data available than a narrative summary where bias can easily be introduced and it is more difficult to assess the impact of moderating variables.

A meta-analysis aims to provide a rigorous and replicable search and summary of the existing literature. Through conducting the meta-analysis, however, I also became aware of a number of times when it was necessary to make decisions regarding the specific rules to apply for paper or data selection. Frequently more than one paper reported data from the same sample, and individual studies (particularly longitudinal) reported numerous effect sizes. Criteria were therefore needed to determine which paper and effect size(s) would be selected such that all studies were treated equally and the approach was internally consistent. Similarly, criteria for the coding of moderators were developed in order that all papers were

treated equally in terms of categorising their differences. This led me to wonder what the impact of these, ultimately somewhat arbitrary, criteria was; would the outcome of the meta-analysis have been different had different rules been applied? Since meta-analysis accounts for variability in effect sizes between studies (indeed this is the target of investigation), and a large number of studies are included perhaps not, however it may well be something I now consider when interpreting the outcome of meta-analyses.

Summary

This section considered some methodological challenges, strengths and limitations of both electroencephalography and meta-analysis. Whilst the limitations are far from sufficient to outweigh the substantial benefits of these approaches, they are likely to be important factors in designing, reporting and consuming research, and in consuming the research of others. They also highlight that there may be more of an 'art' to the process of measurement in scientific research than I had previously considered, and indicate the role of peer review and replication in driving incremental increases in knowledge and understanding,

Pragmatic Challenges and Dilemmas: Recruitment

One of the major challenges throughout the research process was recruiting participants. Families had originally participated in research at the centre in 2007 when their children were aged ten months. Whilst the families gave permission to be contacted, the study was not advertised as a longitudinal investigation. Almost five years had elapsed between originally participating and us making contact again. In this time, many families had moved away from London, had further young children at home and/or mothers had returned to work. In addition, the children were now five or six years old, had started school and were engaged in a host of

extra-curricular activities. These factors all resulted in challenges and dilemmas throughout the recruitment process.

The first dilemma was in the most appropriate means, and frequency, of contacting families. Families were initially sent a letter (see Appendix 3) informing them of the study and explaining that a researcher would be contacting them. We subsequently made telephone contact. If, after a number of weeks, we had been unable to contact the family by telephone, we sent an email with the original contact letter attached. Finally, if we had been unsuccessful in contacting families via telephone or email, we sent one final letter. This letter explained the study again and requested that the family get in touch if they would like to take part (see Appendix 9).

The dilemma around contacting families arose because it was often unclear whether we were unable to make contact because our contact details were out of date, because we were not calling at a convenient time, or because families were screening our calls and did not wish to speak to us. On the one hand, the right to privacy of the families was of the utmost importance, and we were clearly obliged to ensure that our attempts to contact were not invasive or a nuisance. On the other hand, we were also ethically obliged to conduct the study to the highest possible standard; this includes recruiting sufficient participants to ensure a good rate of retention and adequate statistical power.

In order to balance these two competing ethical demands, we ensured that we called at different times of the day and evening, at times when we anticipated we may reach parents of school-aged children, but not more than three times in any given week and not leaving a voicemail every time. We kept clear records about when the family had last been contacted and frequently reviewed our progress and strategy to ensure we were optimising our chances of successfully making contact, without placing undue pressure on the families we were attempting to contact. Our experience was that most frequently, on making contact with a family, the response

was to thank us for getting in touch as they had been meaning to call but had not got round to it.

Unfortunately, there remained a proportion of families with whom we were never able to make contact through post, telephone or email. I noted that in the last decade, means of communication seem to have changed substantially, with email and mobile telephones far more common now than over five years ago, when families were originally recruited. Accordingly, for many families, no email address or mobile telephone number were collected. This meant that our only means of communication (postal address and landline phone) were reliant on families either having remained in the same house, or having updated the contact information held for them at the centre.

Having contacted families, the second dilemma was in discussing the research and inviting families to attend. Again this required balancing the ethical obligations of ensuring informed consent, with conducting high-quality research with sufficient sample size. We needed to realistically describe what the research entailed and what would be asked of the children participating, whilst enticing families to give up two or three hours of their time. We found it helpful to be able to offer appointments after school, at weekends and during school holidays, to reduce the likelihood of parents agreeing in principle to attend but subsequently being unable to find a suitable time to do so.

In light of these experiences, my thoughts on considerations for setting up longitudinal studies are described below:

1. Planning and Transparency – In order to optimise retention rates of the study, participants should be informed of the longitudinal nature of the research at the outset. In as far as is practicable and ethical, an indication of commitment to return for follow-up studies should be sought.

2. Maintaining Contact and Contact Details – An up to date database of contact details is vital for re-recruiting participants for follow-up studies, or inviting

participants to participate in each subsequent wave of a longitudinal study. Our participants were regularly sent a newsletter which seemed to serve to maintain the link between the research institution/researchers and participants, and also provided opportunities to ensure that contact details were being kept up to date.

3. *Time scales* – Follow up assessments should also be sufficiently frequent to maintain contact with participating families, balanced with being sufficiently infrequent that demands on participant's time are not excessive.

4. *Contact Strategy* – The strategy for contacting families, the number of calls and the times at which these calls will be made should be agreed in advance. Communication between members of the research team as to recruitment progress is vital.

Clinical Implications of the Thesis

The importance of effortful control for later adjustment and functioning was considered in the introduction to the literature review. In addition, the field of developmental psychopathology recognises the value of understanding the process and determinants of typical development in order to better understand how difficulties and disorders arise (Cicchetti & Toth, 2009; Sroufe & Rutter, 1984). In light of this, this section therefore considers the clinical implication of these thesis findings.

With regards to the meta-analysis, understanding that parenting behaviour (particular those behaviours relating to emotional aspects of parenting such as warmth and sensitivity) is significantly associated with the development of effortful control provides one particular target for intervention to support the development of effortful control and hence reduce the likelihood of some of the difficulties with which this trait is associated. The meta-analysis also found that effects of parenting appear to be reduced for families in situations of high socio-economic risk. This indicates that targeting parenting behaviour may not be sufficient for this group, and

addressing the social inequalities from which these socioeconomic risk factors arise may also be of potential importance for supporting the development of effortful control.

The empirical paper investigated EEG indices of effortful control, contributing to the growing literature investigating the brain basis of these abilities. As described in the Introductions to Parts 1 and 2 of this thesis, high levels of effortful control are related to a number of positive outcomes including lower levels of externalising behaviour problems (Eisenberg, Spinrad, Fabes, Reiser, Cumberland, Shepard et al, 2004), greater emotion regulation (Carlson & Wang, 2007) and better academic performance (Blair & Razza, 2007). An understanding of how effortful control develops is therefore an important contribution to the body of knowledge regarding one potential process through which behavioural, emotional and academic difficulties may arise. In addition, investigation of the associations between more internally valid laboratory measures and more ecologically valid parent-report measures, is important for determining how research can be translated to the real-world, and the limitations of this.

There are a number of clinical groups for whom difficulties with effortful control, synonymous or highly related attention abilities have been described, including children with ADHD (Martel and Nigg, 2007), children born preterm (Poehlmann, Schwichtenberg, Shah, Schlafer, Hahn & Maleck, 2010) and children subject to severe abuse and neglect during their early years (Stevens, Sonuga-Barke, Kreppner, Beckett, Castle, Colvert et al, 2008). A good understanding of the flanker task properties, and neural indices and brain basis of task performance in typically developing children is a vital prerequisite for investigation of clinical samples such as these. This research, by contributing to our understanding of this process of typical development provides both a point of comparison and suggestions for potential targets for investigation with these clinical groups.

In addition, , it is possible that in future, comparison between typically developing groups and clinical samples may be of diagnostic utility, as is beginning to be proposed with respect to ADHD (for a review see Barry et al., 2003). Rueda, Checa and Cómbita (2012) have also demonstrated effects of training on EEG indices of task performance. It is therefore also possible that these neural indices may, in future studies, be useful tools for objectively assessing changes in effortful brought about by interventions designed to address such difficulties, such as attention training programmes for children with ADHD (e.g. Tamm, Hughes, Ames, Pickering, Silver, Stavinoha, Castillo et al., 2009).

Concluding Reflections

In light of my original view of research as a process of definition and measurement, the first half of this appraisal sought to consider the challenges in these two elements of the research process. The process of conducting the study and meta-analysis has shifted my view that research is a straightforward process of defining constructs, measuring and drawing conclusions from the results. The concepts of effortful control and parenting demonstrate the challenges of defining complex human behaviour in the context of multiple theoretical and methodological approaches. Methodological limitations highlight that there may be more of an art to the process of scientific investigation than I had previously considered and indicate the importance of peer review and replication in the iterative process of advancing scientific knowledge and understanding. These advances in knowledge and understanding are of theoretical and clinical importance, and of equal importance are the conceptual and methodological refinements which also arise in the field over time as a consequence of these processes.

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Appendices

Appendix 1: Moderator Coding Schedule

Site	Country as described in method section/location of university of principle investigator(s).	
N	Number of participants in sample.	
Design	Was the data (effect sizes included in analysis) for parenting and effortful control gathered concurrently or over a period of time (longitudinal).	C - Concurrent L - Longitudinal
Time Gap	Difference between age when parenting and effortful control were assessed.*	Time in months
Sample	As stated in methods section – were efforts made to recruit a high risk/disadvantaged sample? le children with externalising behaviour problems (although clinical child samples were excluded), parental psychopathology, low SES	C - Community HR - High Risk
Parenting construct (C)	Did the measure of parenting assess either 1) emotional aspects of parenting/relationship – sensitivity, warmth, emotional expressivity 2) Structure, boundaries or teaching aspects of parenting – limit-setting, autonomy support, scaffolding.	E - Emotional S - Structure
Parenting task (T)	Was the measure of parenting completed through observation of unstructured time (eg freeplay, 'normal routine'), or a structured task consistent across participants (including being given specific toys to play with) or both?	S – Structured U – Unstructured B - Both
Parenting Location (L)	Was parenting measured at home or in the laboratory, or both?	H – Home L - Lab
Parenting measure ment (M)	Parenting measured by: 1) Observer rating: global evaluation/impressions using Likert scale. 2) Event/time sampling/coding.	O – observer impression rating E – Event coding
IRR	Mean Inter-rater reliability of parenting measure.	
%	% of observations double coded for assessment of inter-rater reliability.	
Effortful Control Measure - Task	How was effortful control measured? 1) Questionnaire – CBQ or equivalent 2) Behavioural measure – observed and scored eg Kochanska task battery 3) Other – more subjective task?	Q – Questionnaire B – Behavioural O - other
Effortful Control Measure – N	Number of subscales used in measurement/evaluation of effortful control.	
Sex	% male in sample.	% male
SES	Socioeconomic Status. Disadvantaged – efforts were made to recruit a low-income sample, with a high proportion of families from low income neighbourhoods or indicating a level of socioeconomic disadvantage.	D – Disadvantaged MC – Middle Class

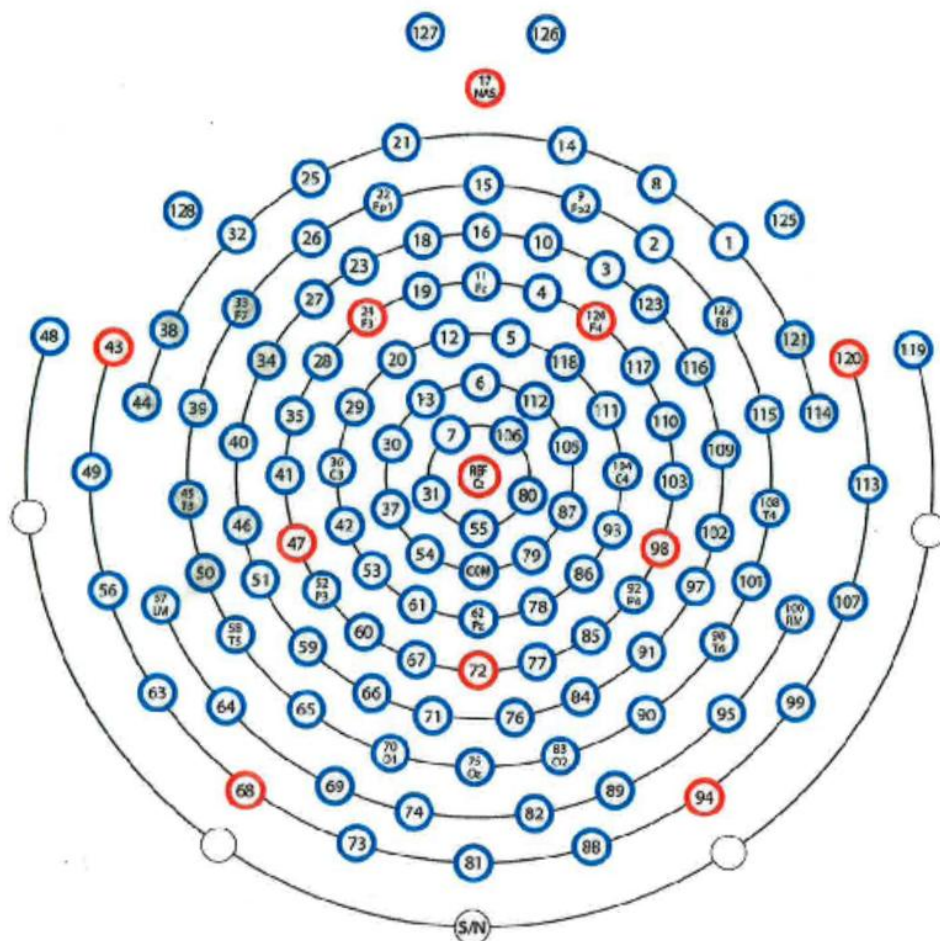
	Middle Class – no efforts were made to recruit a disadvantaged sample.	
Ethnicity	Percentage white European/American of children where available, or mothers if not. (Hispanic is coded as non-white European/American).	% White European/American Not stated
Maternal Age	Mean maternal age reported at the birth of the child. Or mean maternal age at the start of the study minus the mean age of children at the same time point.	Age in years
% two parent families	% of families where household contained two adults, either married or cohabiting. Assumed to equal 100-number of single parent households.	% cohabiting

Notes

-Moderators coded for the data set used for the reported effect size, which may differ from the full sample, or begin at a different time point.

-Where moderators may change over the course of the study (maternal age, % cohabiting), data at the earliest time point are taken.

Appendix 2: 128-Channel Geodesic Sensor Net Electrode Map



Appendix 3: Initial Participant Contact Letter

Dear Parent,

We are writing from the Anna Freud Centre's Development Neuroscience Unit. We would like to invite your child to take part in a new research study. Our study is aiming to investigate how children develop their abilities to control their actions and to understand social situations. Taking part will involve a visit to the Anna Freud Centre in Hampstead for about 2 hours. This visit can be arranged for a time to suit you.

We are contacting you because four years ago you took part in a study at the Anna Freud Centre. When you took part in that study, the researchers gathered information about the relationship between your child and their caregiver. We are inviting you to take part in a study which is following up on this previous research. Being able to follow children over time is very useful to psychology researchers, as it enables us to see how experiences earlier in life might have contributed to their skills and abilities when they are older.

Before you and your child decide whether you would like to take part, it is important for you to know why the research is being done and what it will involve. We will give you a quick phone call to see if you are interested in hearing more about the study in the next week. We have also enclosed an information leaflet, which describes our research in more detail. Please do not hesitate to contact us if you would like to discuss the study further in the meantime.

Many thanks for taking the time to read this. We look forward to hearing from you,

Yours faithfully,

Samantha Taylor-Colles

Sophie Bennett

Sarah Carman

Appendix 4: Participant Information Sheets

PARENT/GUARDIAN INFORMATION SHEET AND CONSENT FORM FOR CHILDREN AGED 4-6YRS

The Development of Controlling Actions and Understanding Social Situations

We are researchers at the Anna Freud Centre's Developmental Neuroscience Unit and UCL who are interested in child development. We would like to invite your child to take part in our research study. Before you and your child decide whether you would like to take part, it is important for you to know why the research is being done and what it will involve. Please take time to read this information sheet carefully and discuss it with others if you wish. If there is anything that is not clear, or if you would like more information, please do not hesitate to contact Sarah Carman or Sophie Bennett on 020 7794 2313.

ud

The aim of the study

We are investigating how children develop the ability to control their behaviour and understand social situations.

Why is the study being done?

We know from studies that have followed children over a number of years that learning to control actions and to understand social situations is an important part of a child's development. How these abilities develop is different for each individual child, and there are many factors that are thought to contribute to the process. We are interested in finding out more about what happens in the brain when children try to make sense of social situations and when they try to control their actions. We are also interested in how these abilities are related to their earlier development, such as their relationships with their carers and their temperament.

We hope that this will give us a better understanding of how children learn to control their actions and understand social situations, including new information about what is happening in their brains when they think about these things. We also hope that in the future, this understanding will eventually help us understand how developmental disorders and mental health problems arise later in life, and will help us to treat those who do suffer from these problems more effectively.

Why have we been asked to take part?

We are contacting you because several years ago you took part in a study at the Anna Freud Centre. When you took part in that study, the researchers gathered information about your child's development and about parent-child interactions. We are inviting you to take part in a study which is following up on this previous research. Being able to follow children over time is very useful to psychology researchers, as it enables us to see how earlier development relates to skills and abilities later in life.

What will happen if we take part?

If you agree to take part, we will invite you and your child to come to the Anna Freud centre, at a time that is convenient for you. The whole thing should take around an hour and a half to two hours. We will reimburse your travel expenses and offer a £5 voucher as a thank you for giving up your time.



Whilst you are here, we will ask your child to play some games on the computer while we measure what is happening in their brain using EEG technology. EEG is a safe and non-invasive method of measuring tiny changes in the levels of electrical activity produced by the brain when we think. We will ask your child to wear a net on

their head, a bit like the picture, whilst they play two computer games. In total, this part should probably take no more than about forty minutes, although it can take some time to put the net on and get ready to play the games.

We will also ask your child to play a game with some toy people characters. We won't ask your child to wear the EEG net whilst they are playing this game. We will ask them to act out different stories with the characters, to look at how they think about different social situations. This should take no more than half an hour. This game will be filmed, so that we can review and rate your child's responses. The data will be transferred from the camera and stored securely on the Anna Freud Centre computer system.

Whilst you are at the Anna Freud centre we will ask you to complete some questionnaires about your child. Please talk about the study with your child. Sarah and Sophie (the researchers) will also make sure that your child understands what he/she will be doing and give him/her an opportunity to ask any questions that he/she may have.

Are there any risks or discomforts?

We do not envisage that the things we will ask your child to do will cause any discomfort. EEG is used very commonly in research with children and is entirely safe and non-invasive. Most children don't mind wearing the net at all, but we will stop if your child is uncomfortable. This study has been approved by the UCL Research Ethics committee.

Does my child have to take part in this study?

It is up to you and your child whether or not you take part in this study. If you do decide to take part, you will be asked to sign a consent form. If you decide now, or at a later date, that you do not wish to participate in this research you are free to withdraw at any time without giving a reason. Even if you are happy for your child to take part, he or she will still decide for himself. It will be explained to your child that he/she can choose to withdraw from the study at any time, without giving a reason. We want to make sure that everyone is happy when taking part in our project.

Will information about my child's performance be available to anyone?

All information collected from you and your child during the course of this research will be kept strictly confidential, unless required by law.

Who will have access to the research records?

Only members of our research team will be able to look at the information we collect. The use of some types of personal information is safeguarded by the Data Protection Act of 1998 (DPA). The DPA places an obligation on those who record or use personal information, but also gives rights to people about whom information is held.

How to contact the researchers

If you would like to know more about this research, you can contact Sophie or Sarah on 020 7794 2313. If you prefer to email, you can contact Sophie on Sophie.Bennett.10@ucl.ac.uk or Sarah on Sarah.Carman.09@ucl.ac.uk.

Thank you for taking the time to read this information sheet

Appendix 5: Participant Consent Forms

The development of executive function and understanding social situations: An EEG study

Consent Form:

If Yes, please complete the following:

☐ I have read the Information Sheet and understand what the study involves

☐ I have had the opportunity to ask any questions I wish to ask.

☐ I consent to the processing of my personal information, and that of my child, for the purposes of this research study

☐ I consent to the researchers accessing and processing the data obtained in the previous study which myself and my child previously participated in, for the purposes of this research study.

☐ I consent to a videotape of my child being recorded whilst they undertake the 'Story Stems' Task. I understand that this video is being used solely for the purpose of data analysis and will be kept securely at the Anna Freud Centre in accordance with the provisions of the Data Protection Act 1998.

☐ I understand that such information will be treated as strictly confidential and handled in accordance with the provisions of the Data Protection Act 1998

☐ I understand that I am free to withdraw my child from the study at any time without giving a reason.

☐ I understand that my child is free to withdraw from the study at any time without giving a reason.

☐ I give consent to be contacted directly by the research team in the future at the details given by me on this form.

☐ I have the names and telephone numbers of the research team in case I have any queries in the future.

☐ I agree that the research project named above has been explained to me to my satisfaction and I agree for my child to participate in the study.

Child's Name: _____ Parent's Name: _____

Signature: _____ Date: _____

Address: _____

Telephone number: _____

Email: _____

1

Appendix 6: Contribution of Each Trainee to the Joint Project

Planning – The design of each study, including developing the EEG tasks and selecting measures, was conducted independently. Research proposals were written individually.


Applications for ethical approval, the development of information sheets and consent forms and overall study protocol were conducted jointly.

Recruitment and Testing – The recruitment and booking of participants was conducted jointly. Each testing session was attended both trainees or one trainee supported by a member of the research centre team. Each trainee was present for at least approximately two thirds of the testing sessions. Data entry was shared.

Data Analysis and Write Up – EEG pre-processing, all data analysis and writing up of the results was conducted individually.

Literature Review and Critical Appraisal – The literature review was conducted and written up independently, as was the critical appraisal.

Appendix 7a: Ethical Approval (initial approval)

<p>UCL RESEARCH ETHICS COMMITTEE GRADUATE SCHOOL OFFICE</p>	
<p>Professor Pasco Fearon Research Department of Clinical, Educational and Health Psychology UCL</p> <p>2 March 2012</p> <p>Dear Professor Fearon</p> <p><u>Notification of Ethical Approval</u> <u>Ethics Application: 3594/001: The development of executive function and social understanding: an EEG study</u></p> <p>I am pleased to confirm that in my capacity as Chair of the UCL Research Ethics Committee I have approved your study for the duration of the project, i.e. until October 2013.</p> <p>Approval is subject to the following conditions:</p> <ol style="list-style-type: none">1. You must seek Chair's approval for proposed amendments to the research for which this approval has been given. Ethical approval is specific to this project and must not be treated as applicable to research of a similar nature. Each research project is reviewed separately and if there are significant changes to the research protocol you should seek confirmation of continued ethical approval by completing the 'Amendment Approval Request Form'. <p>The form identified above can be accessed by logging on to the ethics website homepage: http://www.grad.ucl.ac.uk/ethics/ and clicking on the button marked 'Key Responsibilities of the Researcher Following Approval'.</p> <ol style="list-style-type: none">2. It is your responsibility to report to the Committee any unanticipated problems or adverse events involving risks to participants or others. Both non-serious and serious adverse events must be reported. <p><u>Reporting Non-Serious Adverse Events</u></p> <p>For non-serious adverse events you will need to inform Helen Dougal, Ethics Committee Administrator (ethics@ucl.ac.uk), within ten days of an adverse incident occurring and provide a full written report that should include any amendments to the participant information sheet and study protocol. The Chair or Vice-Chair of the Ethics Committee will confirm that the incident is non-serious and report to the Committee at the next meeting. The final view of the Committee will be communicated to you.</p> <p><u>Reporting Serious Adverse Events</u></p> <p>The Ethics Committee should be notified of all serious adverse events via the Ethics Committee Administrator immediately the incident occurs. Where the adverse incident is unexpected and serious, the Chair or Vice-Chair will decide whether the study should be terminated pending the opinion of an independent expert. The adverse event will be considered at the next Committee meeting and a decision will be made on the need to change the information leaflet and/or study protocol.</p>	

On completion of the research you must submit a brief report (a maximum of two sides of A4) of your findings/concluding comments to the Committee, which includes in particular issues relating to the ethical implications of the research.

With best wishes for the research.


Yours sincerely

Professor John Foreman
Chair of the UCL Research Ethics Committee

Cc: Sophie Bennett & Sarah Carman

UCL Research Ethics Committee, c/o The Graduate School, North Cloisters, Wilkins Building
University College London Gower Street London WC1E 6BT
Tel: +44 (0)20 7679 7644 Fax: +44 (0)20 7679 7043
ethics@ucl.ac.uk
www.ucl.ac.uk/gradschool

Appendix 7b: Ethical Approval (amendment to add video consent)

UCL RESEARCH ETHICS COMMITTEE			
Amendment Approval Request Form			
1	Project ID Number: 3594/001	Name and Address of Principal Investigator: Professor Pasco Fearon	
2	Project Title: The Development of Executive Function and Social Understanding: An EEG Study		
3	Type of Amendment/s (tick as appropriate) <input checked="" type="checkbox"/> Research procedure/protocol (including research instruments) <input type="checkbox"/> Participant group <input type="checkbox"/> Sponsorship/collaborators <input type="checkbox"/> Extension to approval needed (extensions are given for one year) <input checked="" type="checkbox"/> Information Sheet/s <input checked="" type="checkbox"/> Consent form/s <input type="checkbox"/> Other recruitment documents <input type="checkbox"/> Principal researcher/medical supervisor* <input type="checkbox"/> Other * <small>*Additions to the research team other than the principal researcher, student supervisor and medical supervisor do not need to be submitted as amendments but a complete list should be available upon request.</small>		
4	Justification (give the reasons why the amendment/s are needed) The original application included the Story Stems Assessment Protocol (SSAP) as part of the research assessment battery of tests. During the test the child is asked to finish short stories using toy characters. The SSAP has been validated with large numbers of children and standardised data of children's score is available, however in order to use this data the test must be administered in the same, standardised way. This requires that the children be filmed and the tapes subsequently reviewed for rating and analysis. The SSAP therefore requires the use of video to ensure an accurate verbal and visual record of the child's responses, and enables researchers to review parts of the tape more than once to ensure accurate rating, which would not be possible were the rating to be conducted whilst the child were participating.		
5	Details of Amendments (provide full details of each amendment requested, state where the changes have been made and attach all amended and new documentation) In addition to the original proposed protocol, this requested amendment involves including videotaping participants during (and only during) the Story Stems Assessment Protocol task, in order that responses can be subsequently rated according to the assessment manual. Accordingly, the information leaflets and permission forms have been amended and are included along with this application.		
6	Ethical Considerations (insert details of any ethical issues raised by the proposed amendment/s) The filming of children raises issues of parental consent and data protection. These issue of informed consent to being filmed would be addressed through clear information on the information sheet, and a sentence referring explicitly to consent to being filmed on the consent form. With regards to data protection, the films would be stored securely on the Anna Freud Centre computer system, and deleted from the camera immediately after the data had been transferred.		
7	Other Information (provide any other information which you believe should be taken into account during ethical review of the proposed changes)		

<p>Declaration (to be signed by the Principal Researcher)</p> <ul style="list-style-type: none"> • I confirm that the information in this form is accurate to the best of my knowledge and I take full responsibility for it. • I consider that it would be reasonable for the proposed amendments to be implemented. • For student projects I confirm that my supervisor has approved my proposed modifications. <p>Signature: _____</p> <p>Date: 23/07/12</p>
<p>FOR OFFICE USE ONLY:</p> <p>Amendments to the proposed protocol have been <u>Approved</u> by the Research Ethics Committee.</p> <p>Signature of the REC Chair, Professor John Foreman: _____</p> <p>Date: 15/8/2012</p>

Appendix 8: Transcript of Task Instructions

In this game you are going to see five fish in a line. In the middle is a hungry fish. You can make the hungry fish happy by feeding it. The hungry fish is always the one in the middle.

Your job is to press a button to feed the fish and then it will be happy. You press a different button depending in which way the fish is swimming.

If the fish is swimming to the left (this way), press this button to feed it.

If the fish is swimming to the right (this way), press this button to feed it.

When you press the correct button and feed the fish, the fish will be happy!

You need to try and feed the fish as fast as you can, making sure you press the correct button.

If you need a break then you can tell me and we will stop. Otherwise, please try and sit as still as you can.

Are you ready to try it yourself? Shall we practise?

Appendix 9: Final Contact Letter

Dear Parent,

We wrote to you back in September from the Anna Freud Centre's Development Neuroscience Unit, to invite your child to take part in a new research study. We contacted you because four years ago you took part in a study here at the Anna Freud Centre, and we are now following up on this research. In our original letter we said that we would be calling to discuss whether you would be interested in taking part. We have tried to contact you by telephone but unfortunately have been unable to reach you.

The study is aiming to investigate how children develop their abilities to control their actions and to understand social situations. Taking part will involve a visit to the Anna Freud Centre in Hampstead for about 2 hours. This visit can be arranged for a time to suit you. We are aware that many families might now have grown, and children will be in school and lead busy lives. We have slots after school, at weekends and during school holidays.

Being able to follow children over time is very useful to psychology researchers, as it enables us to see how experiences earlier in life might have contributed to their skills and abilities when they are older. As we are only able to invite families who took part in the original research, we would really like to make contact with as many families as possible. Families have begun coming to take part, and the children have generally really enjoyed it. However, we have found that many of the people who took part in the original research have now moved away or we are unable to contact them. Your participation would therefore be really very valuable to the research.

Before you and your child decide whether you would like to take part, it is important for you to know why the research is being done and what it will involve. We have enclosed an information leaflet, which describes our research in more detail.

We would really appreciate it if you could fill in the attached reply slip indicating whether you would be interested in taking part, and return it to us in the stamped addressed envelope.

Many thanks for taking the time to read this. We look forward to hearing from you.

Yours faithfully,

Samantha Taylor-Colles

Sophie Bennett

Sarah Carman

Please fill out the information below and post it back in the stamped addressed envelope.

Please tick as appropriate:

- ☐ I am interested in taking part in the research, please contact me.
(Please complete contact details below)
- ☐ I am not able to participate in this study, however I am happy to be contacted in future.
(Please complete contact details below)
- ☐ I am not able to participate in this study and would not like to be contacted in future.

Please complete the following contact information:

Parent name	
Child's name	
Home phone number	
Mobile telephone number	
Email address	
Address (if different)	
When might be a good time for us to phone you?	

Thank you for your time!